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SOUTH AFRICAN ROCK PICTURES

By
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Curator of Prehistoric Archaeology, American Museum of Natural History

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SOUTH AFRICAN ROCK PICTURES—*Striking artistic achievements of prehistoric man, which tell a story of the dim past and inspire modern artists with their technique*

By N. C. NELSON

Curator of Prehistoric Archaeology, American Museum of Natural History

PRIMITIVE art, both ancient and modern, has long received special attention from the anthropologists and, judging by museum experience, is gradually winning its way also in popular esteem. The reason perhaps is not far to seek. Art has a wider and more instant appeal than science; for while we may appreciate beauty at first glance, time and study are required to reach an understanding of the technicalities involved even in art itself. The reference here is not to music, singing, dancing or story-telling, but to decorative and pictorial art; that is, to permanent objective representations such as in one form or another are profusely exhibited in every anthropological museum.

In the case of the American Museum of Natural History, still adhering to the scientific mode of mass presentation, the artistic features of our various regional exhibits are studied and copied annually by hundreds of art students, with the result that many of the sometimes ancient design elements have long since been readapted to modern usage. A few museums have actually sought to meet this popular demand by rearranging their exhibits so as to stress the artistic features.

There are two special reasons for commenting on primitive pictorial art at this time. One is that the people of New York City were privileged not long ago to view the reproductions of a large series of native African rock pictures brought by Professor Leo Frobenius from Frankfort-on-the-Main, Germany, and exhibited at the Museum of Modern Art. Professor Frobenius has given a lifetime of study to this type of art, has conducted no less than twelve expeditions to widely separated regions of the African continent, has copied thousands of pictures, and has published extensively on the subject. The other reason is that the American Museum has itself recently acquired the series of carefully made copies of similar rock paintings accompanying this article. These were selected from a large series offered for sale by Mr. M. K. McGuffie, a South African artist who has also devoted much time to the study and whose work has been duly complimented by Professor Frobenius himself.

The McGuffie reproductions herewith illustrated all come from one of the richest rock-painting localities in the world, namely, the eastern portion of Cape Province in extreme South Africa, as shown on the map on page 654. Within an area, measuring roughly seventy miles from north to south and one hundred and fifty miles from east to west, over one hundred localities are indicated in which more

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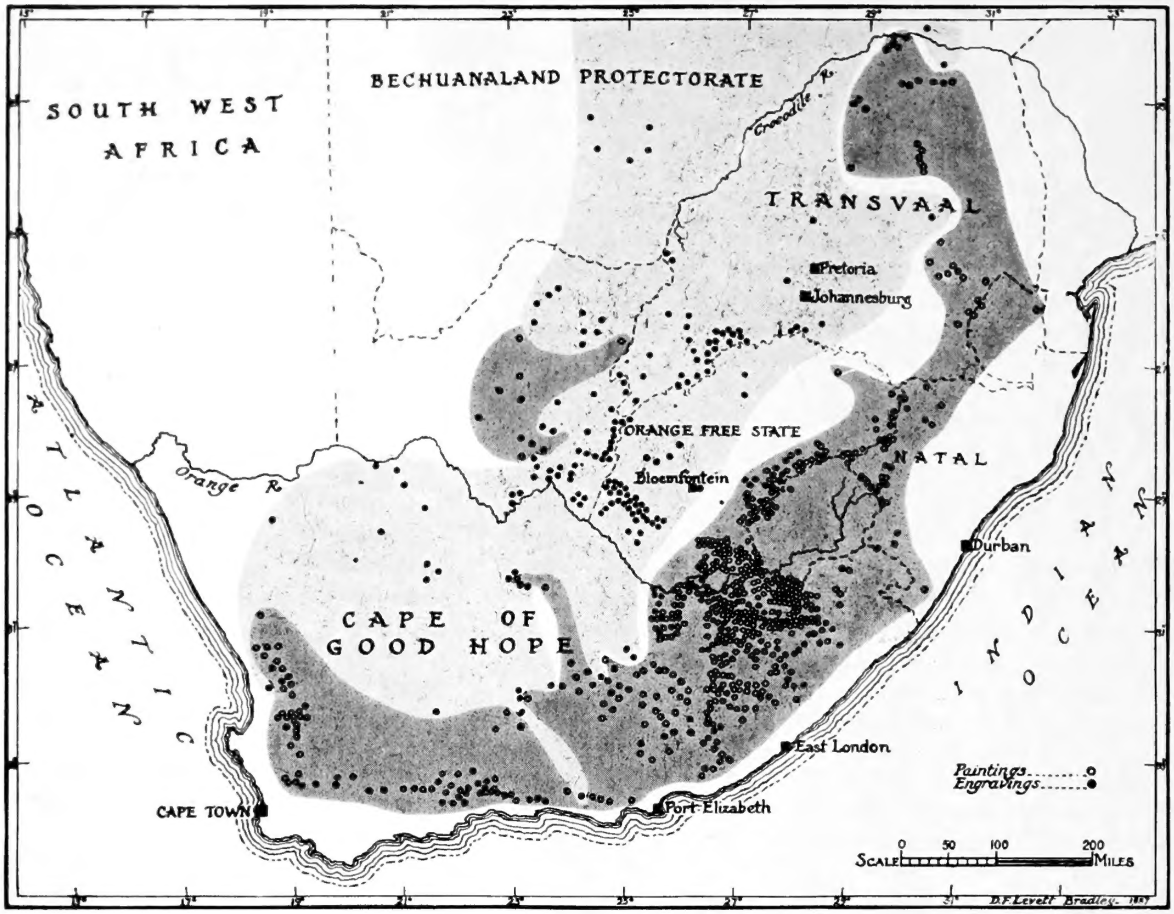
NELS C. NELSON, one of America's most eminent archaeologists, was born and raised on a farm in Denmark. Recalling his early education as a Minnesota farm boy (he emigrated to this country in 1892), Mr. Nelson tells that at the age of seventeen he was spelling C-A-T among classmates that came only as high as his knee. He first became interested in archaeology while attending the Omaha Exposition of 1898 where a graphic history of Man's tools was on display. Mr. Nelson was both a student and a teacher of Anthropology at the University of California and it was in the San Francisco Bay region that he conducted his first major investigations which were later expanded to include the American Southwest. Since that time other sections of this continent together with western Europe and parts of Asia have been explored by Mr. Nelson. As Curator of Prehistoric Archaeology at the American Museum he was in charge of the archaeological branch of Roy Chapman Andrews' Asiatic Expeditions. Mr. Nelson has held official positions in several scientific societies and is an active member of many others. Among the varied archaeological phenomena that have come within the broad scope of his work, are the prehistoric cave drawings of ancient man.



ROCK PAINTINGS AND ENGRAVINGS

Note the abundant sites where this type of primitive art has been found in South Africa. The darker shading indicates the distribution of paintings, the lighter that of engravings. Though the two modes of pictorial representation were presumably the work of the ancestors of the Bushmen, their distribution does not overlap to any marked extent. The drawings reproduced in this article all come from an area approximately 70 by 150 miles (26-29 degrees east and 31-32 degrees south), in which over one hundred localities are indicated

(After the Bureau of Archaeology 1936 map, Department of the Interior, Union of South Africa)

or less extensive groups of rock paintings have been discovered. As seen on the map, however, this area contains only a small fraction of the known art centers in South Africa. Except near the coast, where rock paintings do not occur probably owing to the absence of suitable rock surfaces, they range over a zone in places two hundred miles wide, which parallels the coast for more than fifteen hundred miles. Farther inland, behind this curving zone of rock paintings, there is an equally extensive explored area characterized chiefly by petroglyphs or rock engravings. Curiously enough, although the two modes of pictorial representation were presumably the work of the same people, namely, the Bushmen, their geographical distribution does not appear to overlap to any marked extent.

World distribution of mural art

In passing, it must be made clear that prehistoric rock pictures, both painted and engraved, are not confined to South Africa. Their distribution is world wide. They occur, for example, also in Southwest Africa, in East Africa near Lake Tanganyika, and in various parts of all North Africa, including what is now the Sahara desert. In Europe, relatively re-

cent, i.e., Neolithic, Bronze and Iron Age inscriptions, more or less pictorial, are found in Sweden, in the British Isles, in Belgium, in northwestern France, in northwestern Spain and in Italy. A small series of more ancient rock pictures occur in Russia and Norway; but, as far as is known, the most ancient and in some respects the most noteworthy examples of prehistoric mural art are confined to the caves and rockshelters of southern France, as well as parts of northern and eastern Spain. Asia has furnished at least a few examples from the Near East and from India, and the writer has himself observed a considerable number of rock engravings in Outer Mongolia. Even far-away Australia has supplied some striking examples of both rock engravings and cave paintings. Lastly, needless to say, rock pictures of all types are also an outstanding archaeological feature of both North and South America, being especially numerous in our own Southwest, where conditions for their production and preservation have been particularly favorable.

Mural art styles

Turning now to the Old World, specifically to Europe and Africa, and taking Frobenius for our principal guide, we learn that this vast region is characterized by two distinct art styles. One of these styles he calls Franco-Cantabrian and the other Levantine or Eastern.

The first and probably the older style, best known from southern France and adjacent parts of northern Spain, but found also in various regions of Africa, as, for example, the Atlas mountains, southern Tripoli, and far-away South Africa, is characterized by isolated or individaul representations of mammals, birds, fishes, insects, and human beings. These pictures are mostly polychromes, done sometimes to a scale approaching natural size and often in the manner of faithfully rendered natural poses.

The second or Levantine style, typical of eastern and southeastern Spain, southern Tripoli, the Libyan desert and South Africa, is unique in that the pictures are usually small scale monochromes and represent real compositions or groups, illustrating for the most part hunting or dancing scenes. These pictures are executed in a slightly conventional manner, as may be seen in some of the accompanying illustrations.

The first or Franco-Cantabrian style Professor Frobenius calls "portrait pictures," and the second or Levantine style "action pictures." As the reader must have noticed, the two styles occur together in at least two places, namely, southern Tripoli and South Africa; but in the opinion of several students the first or Franco-Cantabrian style is the older. Apparently, therefore, the two art styles, imitative and interpretive, were practiced by different people through whose various migrations the separate traditions were carried in several directions from the points of origin, probably the lands bordering the western Mediterranean. Professor Frobenius himself appears to maintain the view that both styles originated in southwestern Europe and from there by degrees spread, for example, to South Africa, the Franco-Cantabrian style being the first to arrive. He also regards the African pictures as ranging in time from about 10,000 B. C. down to the present day.

The beginnings of art

As cultural documents these cave wall pictures aside from their esthetic value, constitute one important phase of the middle portion of a long, many-sided story—the story of the development of human civilization. Briefly told for southwestern Europe, where alone it has been well worked out, the art side of this story—giving us the true setting of our South African pictures—is about as follows. Artistic expression, viewed historically and in the large, began in Upper Paleolithic times, some fifteen or twenty thousand years ago, as a crude imitative or realistic endeavor, which slowly improved and then by degrees underwent a process of stylization or schemetization, amounting throughout the succeeding Neolithic Age to almost complete degeneration, at least as far as copying nature was concerned.

At first sight this transformation strikes one as perhaps the natural and therefore the universal law of art development. That is, it seems a clear case of the normal conversion of naturalism into conventionalism or, in more specific terms, pure art giving rise to applied art. Viewed in this light one is tempted to regard it as an illustration of pictorial art, originated and developed by men, giving way to decorative art, practiced mostly by women. One might also argue with some show of reason that the so-called degeneration was more apparent than real because due to inherent necessity. The explanation is this. When the free-hand portrait art, executed on large cave-wall spaces by the early nomadic hunters, was applied by the later sedentary agriculturists to the small surfaces of basketry and textiles, under the limiting conditions imposed by weaving, the naturally flowing outlines of the animals depicted had to be sacrificed for results that were angular and more or less geometric.

But, unfortunately, while both of these suggestions must be given some weight, the fact remains

that women were not the original creators of stylized symbols and geometric patterns, for these appear at an early date as the work of men in the caves alongside the pictorial representations, where they were not the result of necessity. Also, though it is true that some of the geometric conventionalizations, once achieved on textiles, were reproduced on the cave walls and later copied on pottery, pottery surfaces, though small, lent themselves as easily to pictorial representations as did the cave walls. Moreover, elsewhere in the world, as for example in our own Southwest, animal pictures of admittedly inferior character were executed on both cliff walls and pottery throughout most of the Neolithic Age. In Europe, however, this was not the case in any true sense, though here mural art was eventually revived in degenerated form during the Bronze and Iron ages and in the natural course of artistic development improved for distinctly decorative purposes throughout historic times.

A survival

We must conclude, therefore, that pictorial art of the strictly Paleolithic style disappeared from southwestern Europe as a natural result of the decadence of the hunting cultures during Mesolithic times, i.e., actually some time before the dawn of the true Neolithic Age, or about ten thousand years ago. In northern Europe the tradition lingered on for a considerable time, while in Africa it flourished without marked change almost to the present day.

Having indicated the historical position of Old World pictorial art, let us next take a swift look at its contents. The various products of the whole endeavor fall into two grand divisions: stationary art and portable art. By stationary art is meant simply human and animal representations painted, etched or sculptured on cave or cliff walls and therefore permanently fixed. Belonging to this group are also a few examples of clay modeling, similarly immovable and which therefore, like the mural creations, were in a sense public property for everyone to see. Portable art, on the other hand, comprises small objects of all sorts carved in or engraved upon pieces of stone, bone, ivory, antler, shell or wood and which could have been moved about and owned as personal possessions. Both of these art manifestations, fixed and movable, as well as beads, pendants and other forms of bodily adornment, make their first appearance in Europe with the coming of the so-called Cromagnon man. But where precisely the Cromagnon man came from is still a mystery. Possibly it was North Africa; though, if so, it is strange that he appears to have left there next to no remains of portable art objects. Only stationary art is at all well represented here and the same is true, as far as present knowledge goes, for all the rest of prehistoric Africa.

Characteristics of South African pictures

As would be expected, all the earliest artistic efforts were crude. In Europe mural representations of animals, though the subjects must have been very familiar to the artists, began as amateurish profile outline drawings, either deeply incised or painted in a single color—red, brown or black. Depth or perspective was lacking, the animal depicted showing usually only one fore leg and one hind leg. In time this was remedied, with distinctly lifelike results; and in addition full-bodied representations appear, the enclosed contours being stippled, scraped or painted all over, the last process yielding monochrome silhouettes. Finally, the painted monochromes developed into variously shaded polychromes and the etchings or engravings reached a fair degree of excellence as high relief sculptures. This, however, was the course of progress in Europe only, and with that in mind let us turn finally to a brief consideration of corresponding art as practiced in South Africa.

In Africa the earliest examples of mural art are not so easily identified as in Europe. Perhaps the sequence is not complete because the pictures here were executed not in deep sheltering caves but in open rockshelters and the oldest may long since have weathered away. Also it is possible that the art having been introduced, at least in the south, in developed form, the preliminary stage never existed. But, as may be seen in the accompanying illustrations, pecked (sometimes incised) outline and full-bodied pictures are present, as are also both monochrome and polychrome paintings. The mineral colors employed were varying shades of red and brown, also white, black, and on rare occasions yellow and blue. The colors used do not as a rule correspond to the colors of the animals depicted but are arbitrary; and in the case of polychromes the different hues employed for different body portions meet abruptly without intermediate shadings. Some students are of the opinion that the prevailing colors varied from time to time and that in this way some four or five sequential stages may be distinguished. Thus the first or oldest pictures are thought to be monochromes in reds and yellows, the second series are in deep reds and browns, the third in light red, the fourth polychromes of various hues, and the fifth and last simple blacks and whites. Other investigators present the order of succession in more general terms: monochromes, polychromes,

and a final series showing a marked decline.

Concerning the essential characteristics of the art as art, i.e., as to drawing, perspective, composition, rhythm and so on, little can be said here. Technique and style are there, but the illustrations must be left to speak for themselves. As may be seen, the outstanding features are realistic. Conventional symbols, idols, and fabulous creatures are either rare or absent. In this respect the art, although certainly affecting a unique, almost modernistic flair, comes much closer to the natural model than does the art of the African negro. Here is depicted, as a rule, only the realities of daily experience: animals running, grazing, falling or lying down; also men hunting or dancing, with and without disguise; and occasionally men in council and in procession. The pictures must, in short, be attributed to a people of essentially the same mentality or cultural status as the Paleolithic hunters of Europe. And these people are by common consent supposed to be the slowly vanishing Bushmen.

Age of the South African pictures

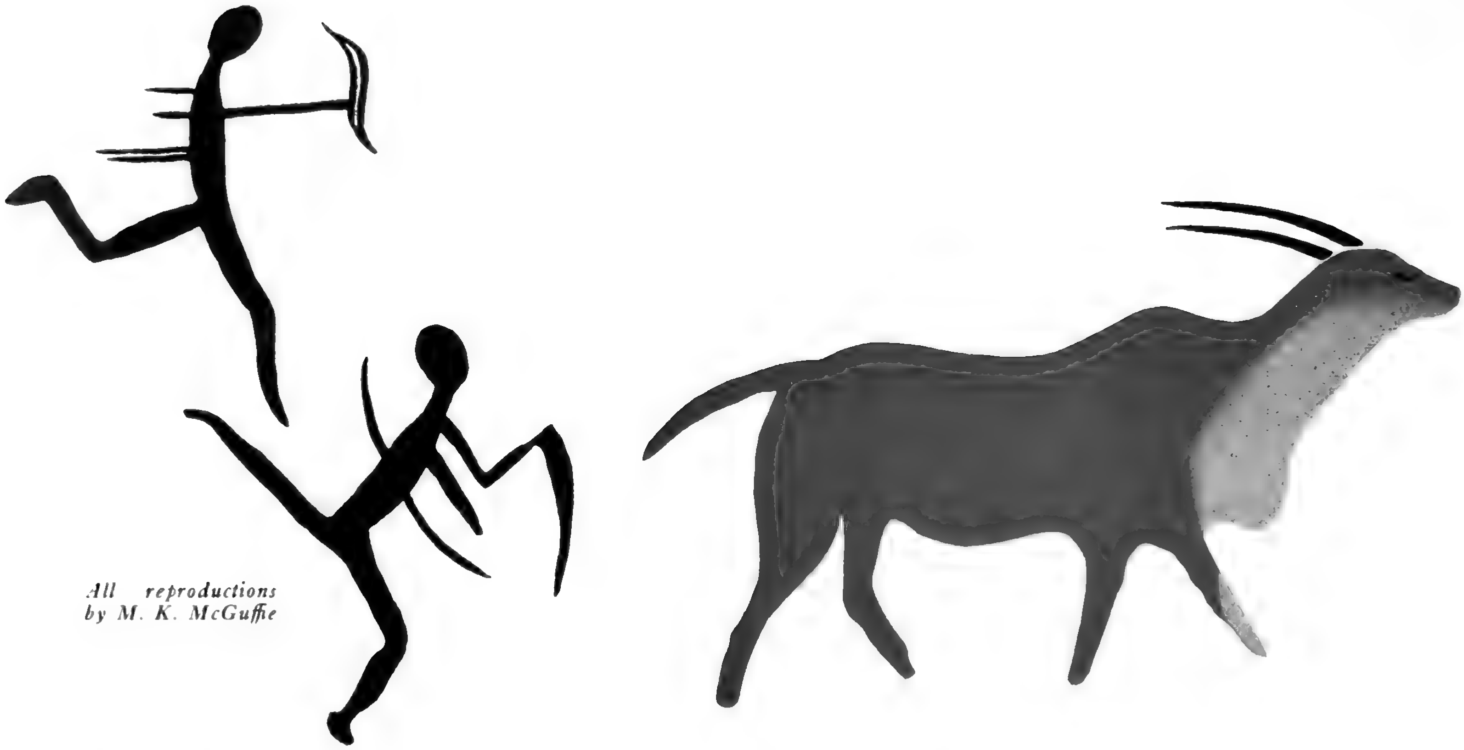
Everyone will ask: How old are these South African art treasures? The answer is, no one knows precisely. It is generally agreed, however, that the most ancient may be several thousand years old and it is definitely known that the latest were made by the Bushmen as recently as seventy-five years ago. But the Bushmen were not the first inhabitants of South Africa and so it is possible that some of the oldest rock pictures may antedate their coming and are to be credited to another people. In either case it is reasonably certain that the South African pictures were made by a people who, as in Upper Paleolithic times in Europe, made specialized implements adapted from flint flakes and not, as in earlier days, crude generalized implements improvised from cores.

Significance of rock pictures

In conclusion, a few remarks must be ventured about the meaning and purpose of the rock pictures in South Africa and elsewhere. As the reader must already suspect, the question, long under dispute, remains largely unanswered. Surviving primitive peoples seldom have any explanations to offer and the opinions of students differ widely. Some have held that most of the inscriptions were the work of idle hours and as such have no more profound meaning than the improvisations made by modern boys and girls on the fence and sidewalk; that, in short, they merely satisfied an innate craving for expression. Others claim that we have something more than that, in fact purposeful art for art's sake. Still others—and these are in the majority—have invested the pictures with a religious or magical purpose. Thus they claim, and with good reason, that the animal pictures, for instance, were part of an incantation process carried out to ensure success in hunting the real animals. Such ceremonies have actually been witnessed in Africa, where natives before going on a hunt first drew on the ground a picture of the animal wanted and then while mumbling incantations over it shot arrows into the picture—a form of well-known sympathetic magic. Some of the compositions actually depict hunting and dancing scenes, both of which may well have had magical purposes. Others may have illustrated mythological conceptions or may have recorded important events in tribal history.

We can follow the fascinating subject no farther. Probably all the above suggestions have to be taken into account. The peoples who made the ancient pictures were not so very different from ourselves and we may safely assume that their artistic achievements served much the same purposes as our own. Art is an essential function of life, explain it how we may.

THE DANCE, which next to hunting was the most popular subject of the prehistoric artist



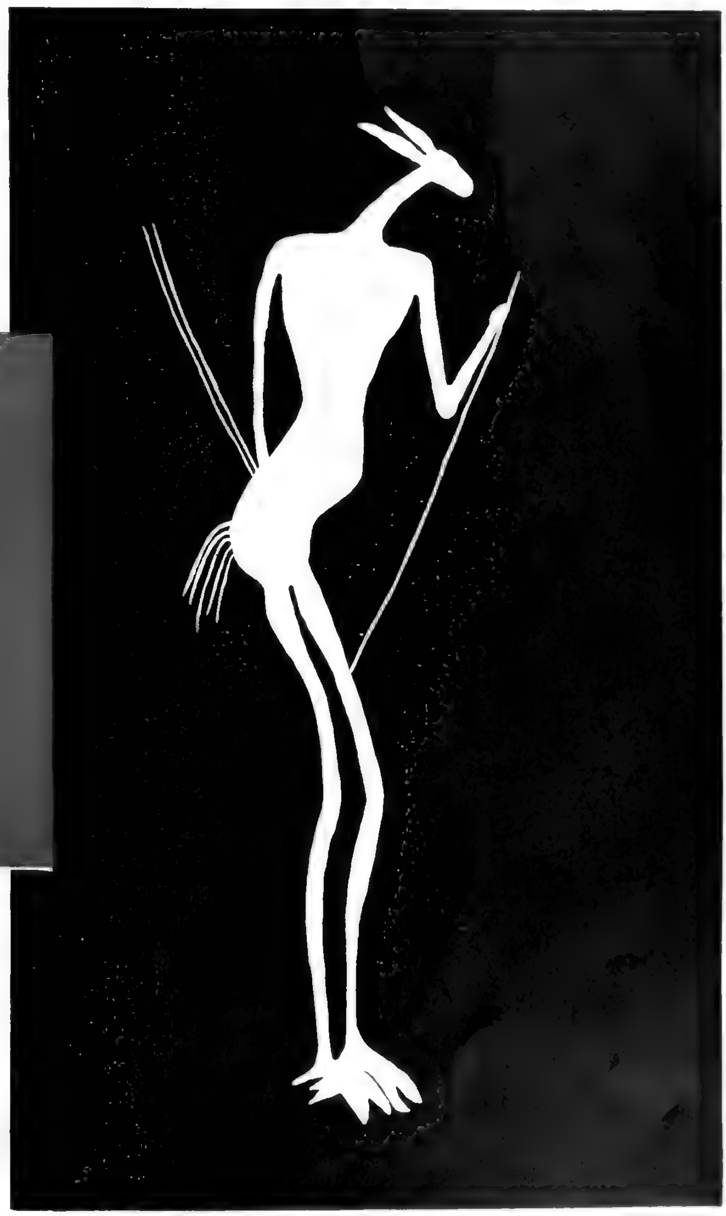
All reproductions by M. K. McGuffie

(Above) THE CHASE: two elands pursued by a pair of hunters. The streaks at rear of the upper figure represent arrows; in front of him is a badly drawn bow. Compare the tail of the central eland with the one at right: the lower human figure is believed to have just chopped off the end of it with the weapon in his hand, probably a stone axe. This hunter carries his bow slung across his body

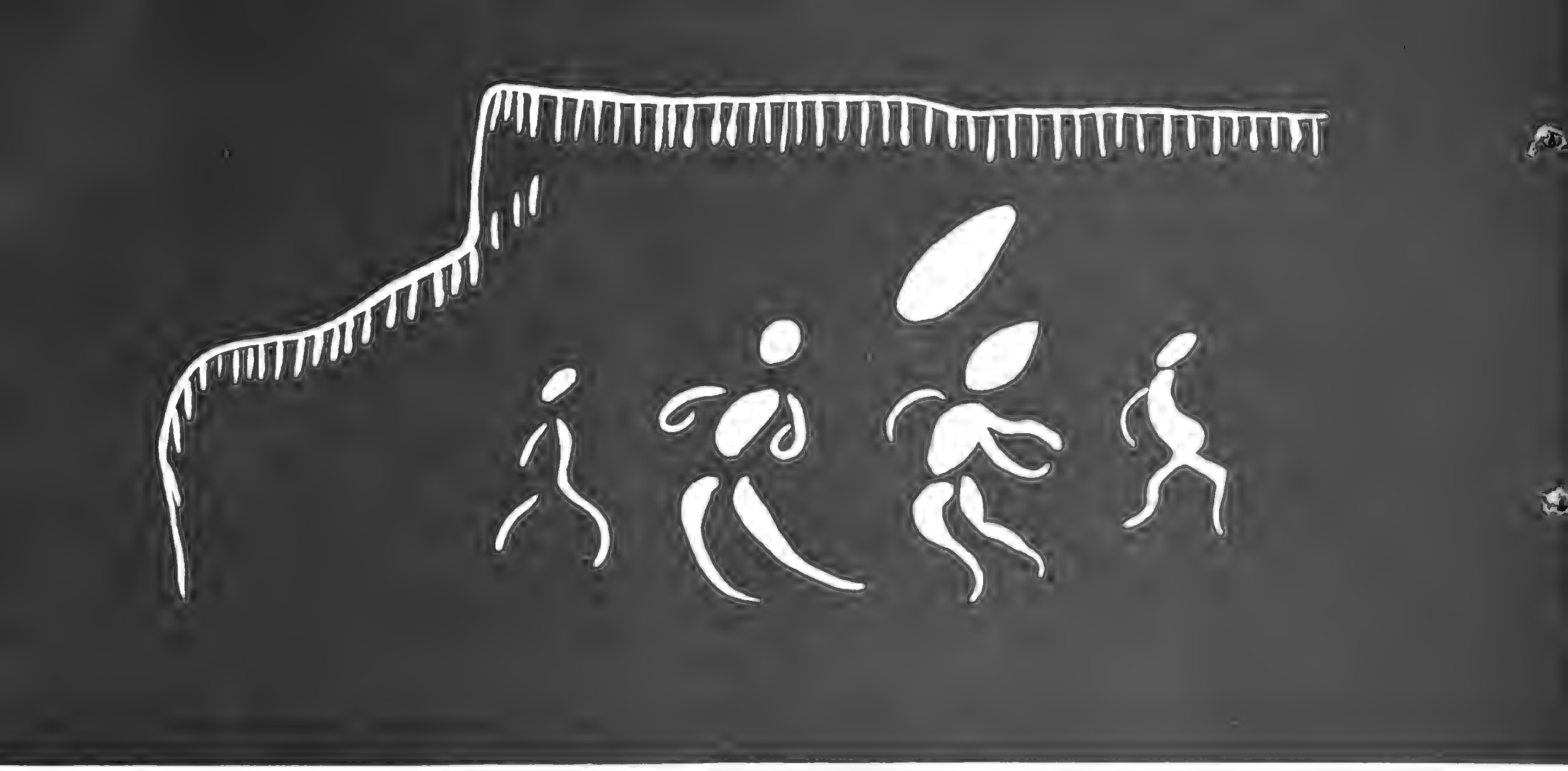
(Above) THE PRANK: a boy with two puff-adders scaring his companions. Notice how the primitive artist expresses flight and abject terror with the greatest economy of detail, a technique copied by many modern artists. The rock gallery where this picture was found is near a river infested with snakes, which form quite an important part of the modern Bushman's food. The latest of these South African art treasures were made as recently as 75 years ago by the Bushmen; the most ancient may be several thousand years old and denote a mentality and cultural status similar to that of the Paleolithic hunters of Europe

Two broad types are distin[illegible] primitive rock pictures wide[illegible] Africa and Europe: (1) "portrait[illegible] resenting single animals or human [illegible] in varied colors and relatively [illegible] (Franco-Cantabrian type); and (2) "acti[illegible] tures" of groups illustrating for the [illegible] hunting and dancing scenes, usually in monochrome and small in scale (Levantine or Eastern type). The South African pictures are definitely "action pictures" (though not always in monochrome), and are in the tradition of the Paleolithic style which disappeared from southwestern Europe about 10,000 years ago. They present an almost modernistic flair in their freedom, realism and absence of conventionalized symbols

(Below) THE FIGHT: a battle between two Mantis-Men, or Kaggan. Symbolizing the courage and combative nature of the insect known as the praying mantis, the Mantis-Man is regarded by the Bushmen as a spirit of mischief and is a favorite subject of the rock painters of old. In this grotesque picture, conveying a sense of fierce action, the weapons so vigorously wielded seem to be a wooden club, hook, spear and stone-headed axe

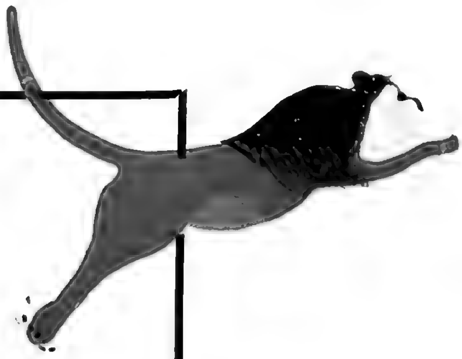


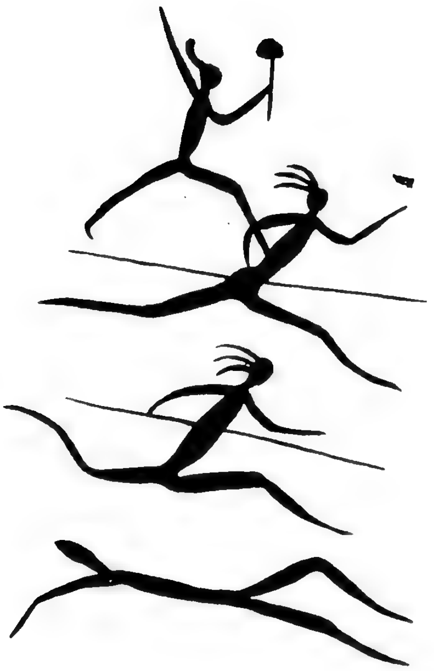
(Right) THE MANTIS-MAN: a mythical creature apparently important in the spiritual philosophy of the ancient artists. As in this example it is frequently presented as a hunter wearing a buck's head-mask and always with long thin legs. Today the mantis is referred to as the "Hottentot god," and when one alights on a Bushman he will sit perfectly still until it flies away



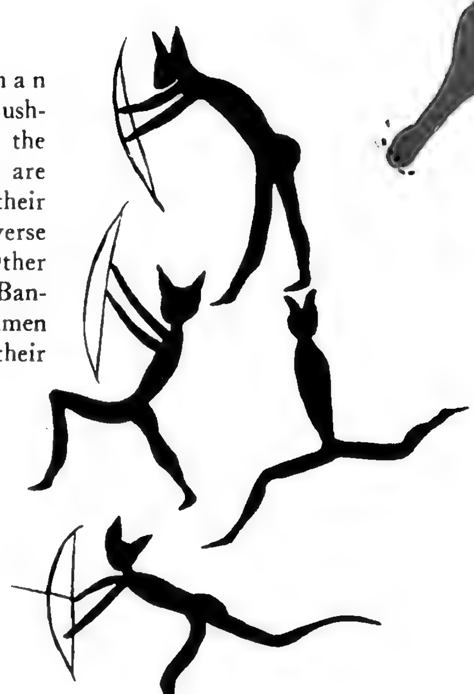
(Above) THE RAIN-MAKERS: an ancient depiction of a ceremony for bringing rain. Legend has it that the "Rain Bull" and the "She Rain" (mythical animals) were led to an appointed place by the witch doctor of a Bushman clan, and there slain so that the rain might descend and produce the plant-life on which the Bushmen depended for food. This painting shows evidence of being extremely old

(Below at right) THE CHARGE: a black-maned lion pursuing a group of fleeing men. In the original picture, a veil-like film of black has been traced over the yellow ochre of the lion's shoulders, apparently intentionally as it cannot be accounted for by rock exudation. This latter phenomenon is effacing many of the pictures in this particular gallery, and total disappearance is only a matter of time





THE BATTLE: Bushman versus Bantu. Since a Bushman drew the picture, the enemy Bantu, at left, are shown as smaller than their rivals, although the reverse is true in actual life. Other pictures ridicule the Bantu's large feet. Bushmen pride themselves on their dainty extremities



(Right) THE RITUAL: a picture probably intended to represent a nocturnal ceremony as indicated by the artists having chosen a poor surface of dark rock for it instead of better mural surfaces above and below. The crosses at top are stars, the pear-shaped objects at right are flames or sparks of a fire rising from horizontal faggots. Ostrich plumes and animal heads appear to be part of the ornamentation of the weird figures

(Below) THE AMBUSH. This picture shows a hunter, camouflaged by quills on his back and hands, stealing up on the two birds he hopes to shoot. It is possible that arrows are concealed in the quills on his hands. This species of ground bird is called the Kornhaan (pronounced Koraan), is excellent food and is now protected by law

(Above) THE WILD-PIG HUNT: a scene which like many others is believed to be part of an incantation process to insure success in hunting. The dogs at upper left are apparently aiding in the chase. The sling-like weapon is judged to consist of three perforated stones on separate strands

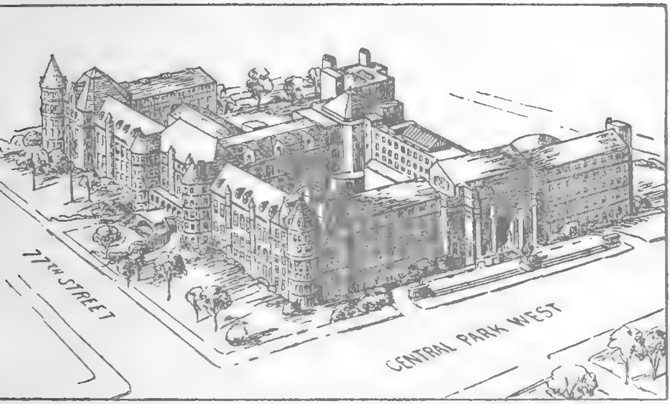
(Below) AN ELAND pecked in rock: an example of the primitive rock engravings, which extend over a wide area in South Africa. Although geographically they do not overlap the paintings, both are believed to be the work of the same people, the ancestors of the present Bushmen

Photo A.M.N.H. and Charles H. Coles

Pocket Guide to the Exhibits

in

The American Museum of Natural History



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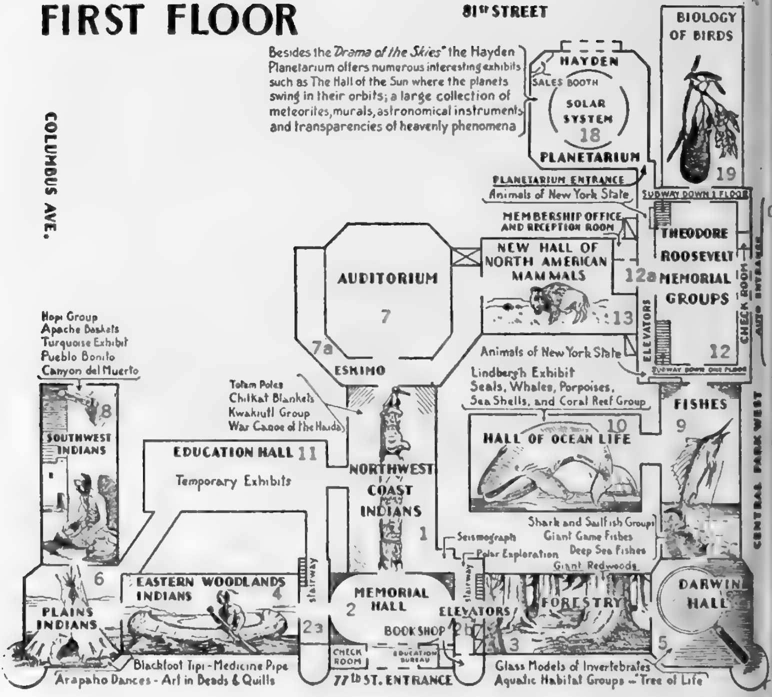
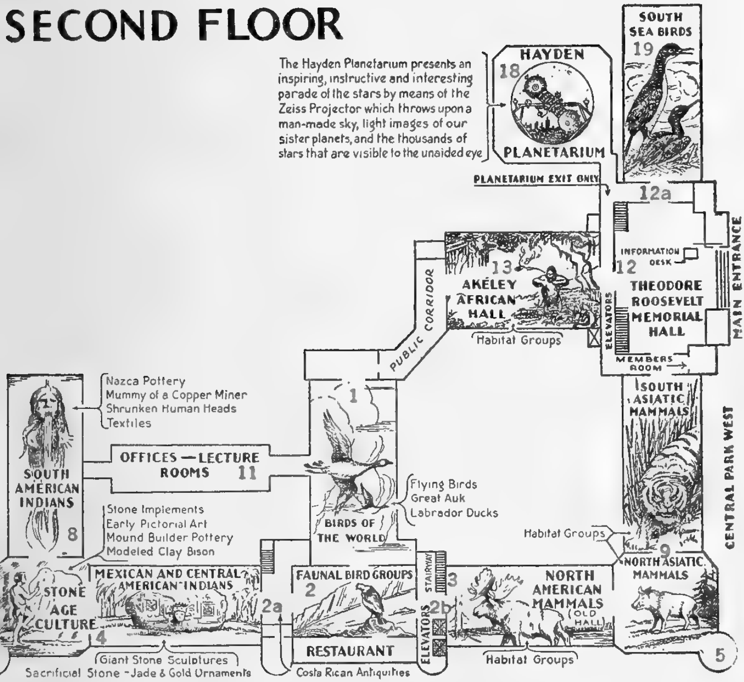
FIRST FLOOR



Index Plan for First Floor of Museum

II

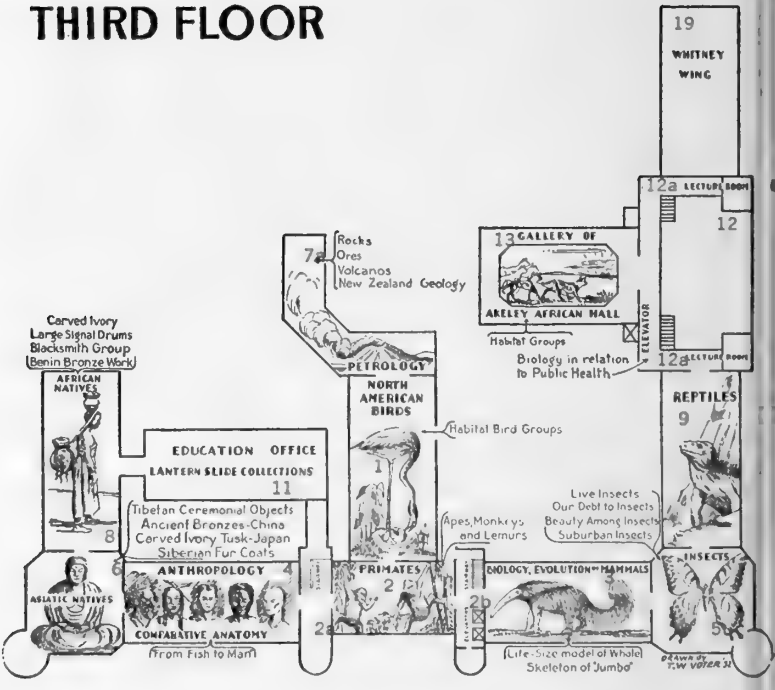
SECOND FLOOR



Index Plan for Second Floor of Museum

III

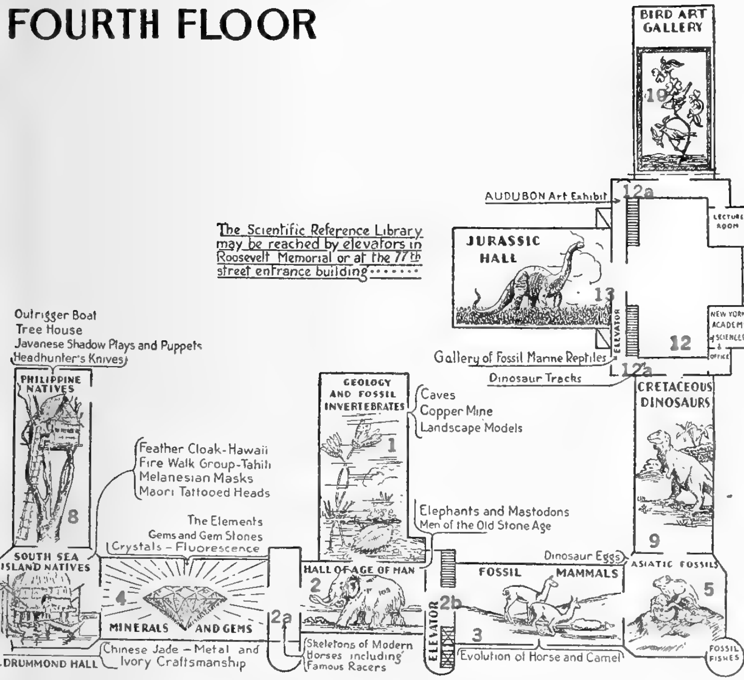
THIRD FLOOR



Index Plan for Third Floor of Museum

IV

FOURTH FLOOR



Index Plan for Fourth Floor of Museum

THE American Museum of Natural History occupies most of the space between Central Park West and Columbus Avenue and 77th and 81st Streets. The main entrances are on Central Park West, through the Roosevelt Memorial, at three levels, street, vehicle (driveway beneath the steps) and subway. There is also an entrance on West 77th Street (foot and vehicle, center of block), and one on Columbus Avenue, near 77th Street (foot).

The Planetarium may be entered from West 81st Street (vehicle and foot) and through the Museum.

There are 13 acres of Exhibition Halls in the American Museum, none being above the fourth floor. This leaflet presents an alphabetical list of the exhibits and a statement of the floor and hall in which they may be found. It is designed only to acquaint the visitor with the nature of the exhibits as a whole and to guide him to those he wishes to see. For example, assuming the visitor wishes to see an exhibit of the Birds of the World, he refers to **Birds** and, under this heading, finds that it is placed on floor II, hall 1. Having reached floor II (there are elevators in the Roosevelt Memorial and near the 77th Street entrance) he refers to the diagrams on pages 2 to 5 of this leaflet and finds the location of hall 1 on Index Plan of Second Floor.

General and special guides to the exhibits themselves may be purchased at the Information Desk (near the main entrance, Roosevelt Memorial Hall, II, 12) and at the Book Shop (near elevator, 77th Street entrance, I, 2b). Specific information may be secured at the entrances and from Museum attendants throughout the building.

All halls are open from 10 — 5 daily except Sundays, Independence Day, Thanksgiving, Christmas and New Year's Day, when they are open from 2 — 6. There is no admission charge except for the Planetarium.

Airplane (see Lindbergh exhibit). **I, 10.**

African Ethnology, Hall of,

Life size models of racial types, iron work, ivory and wood carving, Benin bronzes, etc. **III, 8.**

Age of Mammals, Osborn Hall of,

The evolution of the horse and of the camel. Rhinoceroses. Titanotheres. Early mammals. Murals of North American Tertiary mammals. IV, 3.

Age of Man, Osborn Hall of, (see Guide Leaflet No. 52).

Ancestry of man and of apes. Prehistoric races of man. Evolution of the Proboscidea (mastodons and mammoths). Murals relating to early man and to the Pleistocene faunas. Ground sloths and other animals contemporaneous with early man. IV, 2.

Akeley Memorial Hall of African Mammals.

Habitat groups of the most important mammals and some birds of Africa; fourteen groups and the central herd of elephants on the main floor and fourteen groups on the balcony. II, 13; III, 13.

Allen Hall of North American Mammals.

Habitat groups of some of the large mammals of North America; individuals of other species; model of sulphur-bottom whale. **II, 3.**

Alligators. **III, 9.**

American Indians (see Indians).

Amphibians and Reptiles, Hall of,

Habitat groups and synoptic series showing the evolution, distribution, and biology of reptiles and amphibians; anatomy and life history of selected groups, biological principles illustrated by reptiles, snake-bite treatment, economic importance of reptiles; live reptiles and amphibians. **III, 9.**

Amphibians and Reptiles of New York.

Specimens of the amphibians and reptiles of the state. **I, 12a.**

Amphibians and Reptiles, Live Specimens.

Illustrating principles of distribution and ecology. **Basement, 12.**

Amundsen Polar Expedition Memorabilia (see Geography). **I, 2b.**

Anatomy, Human and Comparative (see Age of Man; Man, Nat. Hist. of). **IV, 2; III, 4.**

Animal Behavior, Hall of,

Living animals in natural habitats. Magnification and projection of living microscopic animals. Various scenes as they are thought to appear to different animals. Intelligence and social life of animals. **Basement, 12.**

Anthropology.

(See under: African Ethnology, Archaeology, Asiatic Anthropology, Eskimos, Indians, Natives, Natural History of Man, Pacific Islands, Philippine Hall).

Archaeology, Central American, Mayan and Mexican.

Models of temples, calendar stone, sacrifice stone, sculpture, manuscripts, pottery, jade and gold ornaments. **II, 4.**

Archaeology, Old World.

Cave art, the Stone Age, Bronze Age, Iron Age, etc. **II, 6.**

Archaeology, South American, West Indian. **II, 8.**

Archaeology, United States and Canada. **II, 6.**

Archaeology. See also Indians, South America; Indians, Southeast, Southwest; Indians, Woodland; Age of Man.

Asiatic Anthropology.

Siberia: models, fur garments, ivory carvings, etc. China, Tibet, Japan, Korea, India: bronzes, jades and religious objects (see also Drummond Hall, **IV, 6**). **III, 6.**

Asiatic Hall.

(Regional Fossil Vertebrates). Mongolian dinosaurs, dinosaur eggs. Mongolian Tertiary and Cretaceous mammals and reptiles. Baluchitherium, largest land mammal. Dean Memorial Collection of fossil fishes (see Guide Leaflet No. 81). **IV, 5.**

Asiatic (North) Mammals (see Mammals). **II, 5.**

Asiatic (South) Mammals (see Vernay-Faunthorpe Hall). **II, 9.**

Asiatic Natives (see Asiatic Anthropology). **III, 6.**

Floors in Roman figures, halls in Arabic.

Floors in Roman figures, halls in Arabic.

Floors in Roman figures, halls in Arabic.

Fishes, Hall of Fishes of the World (see Guide Leaflet No. 81).

Systematic collection and representative species. Special exhibits showing locomotion and development of fishes. Big game species (with trophies of Zane Gray, Michael Lerner, Keith Spalding, and others). Bimini Group, Whale Shark, Manta, Deep Sea Fishes, Barrier Reef Group. **I, 9.**

Fishes, Embryology of. **I, 12a.**

Fishes, Fossil. Dean Memorial Collection (see Guide Leaflet No. 81). **(Tower Room) IV, 5.**

Forestry and Conservation, Hall of. **I, 3.**

Fossil Reptiles.

Flying reptile mural. Dinosaur tracks. Ichthyosaurs; Plesiosaurs; Mosasaurs (see also Asiatic Hall, **IV, 5,** and Dinosaurs, **IV, 9, 13**). **IV, 12a.**

Fossils, Human (see Age of Man).

Fossils, Invertebrates (see Geology).

Fossils, New York State (see New York State Fossils).

Fossils, Plants (see Geology).

Fossils, Vertebrates (see Age of Man; Age of Mammals; Asiatic Hall; Dinosaurs; Fossil Reptiles; Fossil Fishes. **IV, 5.**).

Frogs. **II, 9.**

Gallery of Bird Art.

Originals of paintings and sketches by well-known bird artists. **IV, 19.**

Gems (see Minerals and Gems). **IV, 4.**

Geography (see also Geology).

Pro-geographic Hall. Polar maps; sleds of Peary, Amundsen, and Ellsworth. Polar exploration memorabilia. **I, 2b.**

Geology, and Invertebrate Palaeontology, Hall of,

The preservation and significance of fossils. Pre-Cambrian rocks and ores. Fossil plants and fossil invertebrates, variously grouped by geologic periods and by classes. Topo-geologic and paleogeographic models. Model of copper mine. Cave grottoes. Model of Geology of Hudson River Region (see also Geology—Corridor, **III, 7a; I, 12a**). **IV, 1.**

Floors in Roman figures, halls in Arabic.

Geology—Corridor.

Geological relief models. Volcanos, paintings and specimens. Ores, rocks, New Zealand Geology; open cut copper mine model (see also Geology and Invertebrate Palaeontology, **IV, 1**). **III, 7a.**

Geology of New York State. **I, 12.**

Giant Panda Group. **II, 5.**

Glass Flowers, Menken Collection of (see Hall of Forestry and Conservation). **I, 3.**

Gold Ornaments, Mexico, Central America, Colombia, Ecuador and Peru (see Archaeology). **II, 4; II, 8.**

Growth of Man (see Man, Nat. Hist. of). **III, 4.**

Guided Tours at Information Desks, Roosevelt Memorial, **II, 12**; 77th Street Foyer, **I, 2.** Special Guide Service (see Education, Department of, **II, 11**).

Guide Leaflets of Exhibits for sale in vending machines. **I, 4, 5, 10; III, 4; IV, 2, 4.** (see also Information Desk, Roosevelt Memorial Hall, **II, 12** and Book Shop, **I, 2, 2b**).

Hayden Planetarium (see also Astronomy).

The Drama of the Sky in the Projection Chamber on the second floor is the chief feature of the Hayden Planetarium. Here, in the 75-foot circular room, a composite magic lantern projects on the dome-shaped ceiling the beauty of the day-time and night-time sky, the ever-changing beauty of stars, planets, sun and moon.

PLANETARIUM SCHEDULE & PRICES, 1942

Weekdays ....2, 3:30 & 8:30 P.M.
Saturdays.........11 A.M., 2, 3, 4, 5, & 8:30 P.M.
Sundays & Holidays.......2, 3, 4, 5, & 8:30 P.M.
Admission, Matinees 30c—Evenings 40c (tax included)—Children, under 17 years of age 20c at all times.

Exhibits—(occasionally changed). For fixed exhibits see Astronomy, **II, 18**; entrance from 81st St. and from **II, 12a; I, 12a.**

Horse, Evolution of (see Age of Mammals). **IV, 3.**

Floors in Roman figures, halls in Arabic.

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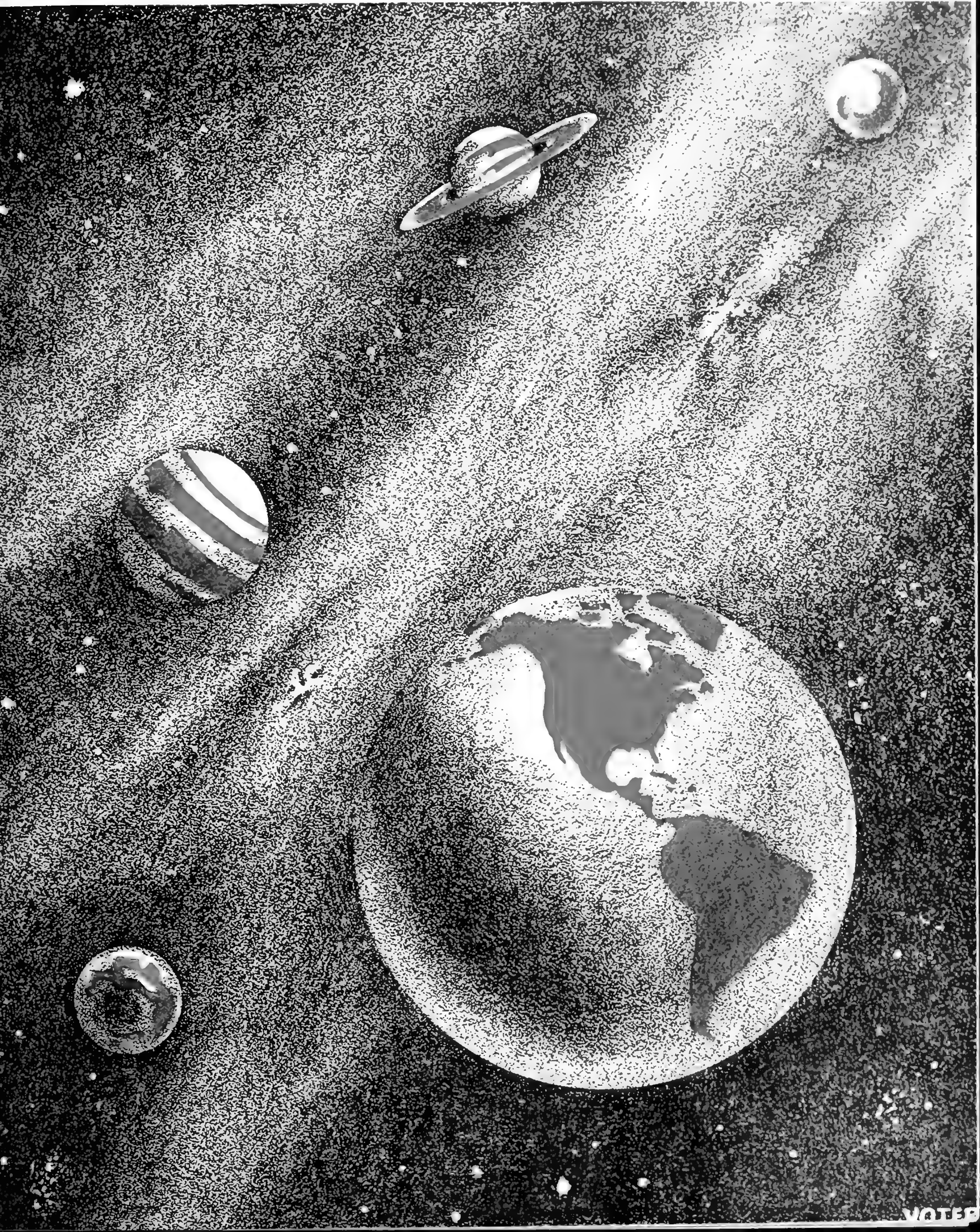
EARTH AND NEIGHBOR WORLDS

BY CLYDE FISHER



EARTH AND NEIGHBOR WORLDS

By

CLYDE FISHER
Curator of Astronomy and Curator-in-Chief of
The Hayden Planetarium

GUIDE LEAFLET SERIES
of the
AMERICAN MUSEUM OF NATURAL HISTORY
No. 95

THE HAYDEN PLANETARIUM
CENTRAL PARK WEST AT 81st STREET
NEW YORK, N. Y.

1938

EARTH AND NEIGHBOR WORLDS

By CLYDE FISHER, Ph.D., LL.D.,

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American Museum of Natural History,
New York City.

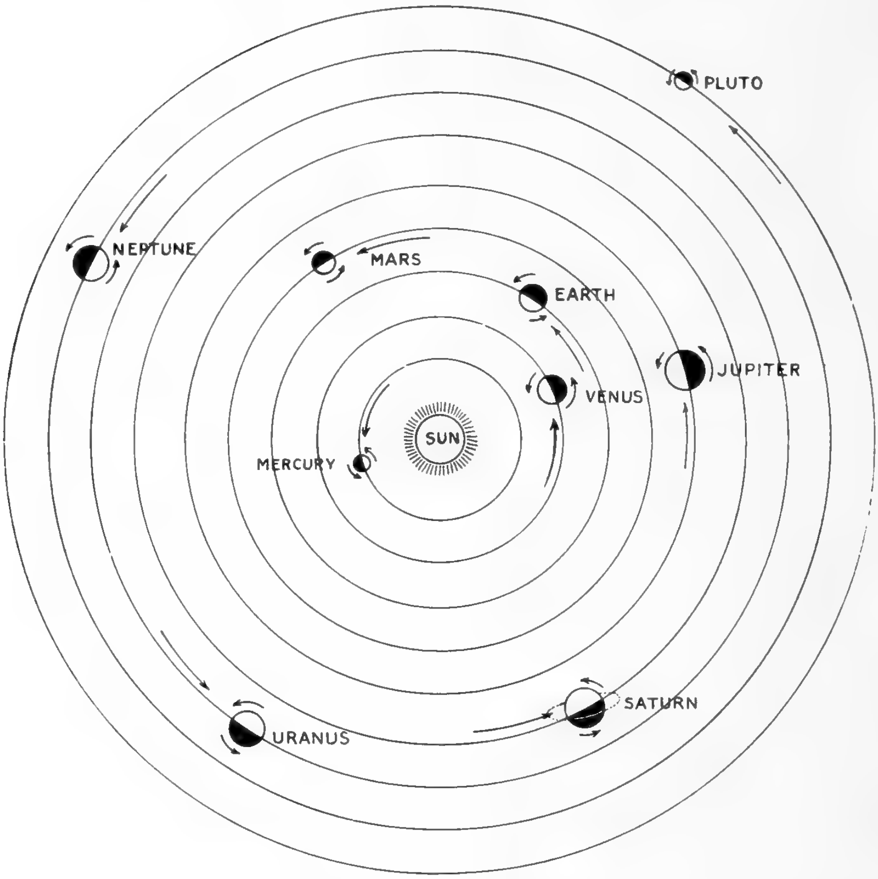
THE planets are members of the same family that includes the Earth. In fact, the Earth is just one of the planets. When a planet sets in the evening after the Sun, it is called an evening star; when it rises in the morning before the Sun it is known as a morning star. The planets, however, differ greatly from the stars. The planets are worlds, all of which revolve around our Sun, and they all go round the Sun in the same direction. Their paths lie so nearly in the same plane, that they occupy only a narrow belt in the heavens, called the zodiac.

While the planets, as the name indicates, wander about in the sky, they do not wander everywhere. No one has ever seen Venus in the Big Dipper, nor Mars in the Southern Cross, nor Jupiter in Cassiopeia. It is evident that the planets are under the control of the Sun. They are all comparatively cold, and shine only by reflected sunlight. On the other hand, the stars are all suns and, being very hot, shine by their own light. It is often said by way of distinction that stars twinkle and planets do not. While this distinction is in general true, yet the planets are apt to twinkle somewhat, especially when near the horizon, due to the increased disturbance of their light by refraction phenomena. The movement of the planets against the background of the stars is distinctive, although it takes a comparatively long time to determine it.

Before the time of Copernicus, it was generally believed that the Earth was the stationary center of the universe, and that the planets as well as the other heavenly bodies revolved around the Earth. It was observed that the planets moved most of the time eastward through the sky, but it was noticed that periodically they moved for a short time westward. This so-called retrograde motion was explained by Ptolemy, the great Alexandrian astronomer, by means of epicycles, that is, circles upon circles. To take Mars as an example, he believed that Mars moved around a small circle, the center of which moved around the Earth in a larger circle. Thus he was able to account for the backward or retrograde motion of a planet.

Now, we are quite sure that the Earth is not the stationary center of the universe, and that the planets including the Earth go around the sun. Consequently we must seek another explanation of the westward or retrograde motion of the planets. We are now quite sure that this retrograde motion of the members of the Sun's family is not real, but apparent; that the planets always move from west to east around the Sun; and that they only *seem* to move westward periodically for a short time when they are closest to the Earth. To take Mars again as an example: when it is nearest the Earth—that is, when it is on the opposite side of the Earth from the Sun—it seems to move westward for a few weeks, because the Earth is moving in the same direction around the Sun, but at a greater speed on a path that is shorter, being inside the orbit of Mars. The Earth goes around the Sun in 365¼ days, while Mars requires 687 of our days to make its journey.

It may make the matter clearer to compare the Earth to an express train and Mars to an automobile truck traveling in the same direction on a highway that parallels the railway. As the express train is



THE SUN AND ITS FAMILY

Chart showing the order of the nine major planets in relation to the Sun and to each other.

overtaking and passing the truck, a passenger would see the truck projected against the landscape beyond in such a way that the truck would appear to be moving backward. In the same way, Mars when observed projected against the background of the stars seems to be moving westward as the Earth passes by.

As shown by Kepler, the planets all move around the Sun in elliptical orbits, the Sun being at one focus of each ellipse. It is true that all the elliptical paths of the major planets are nearly circular in shape.

Of all the planets, Mercury is closest to the Sun, being only 36,000,000 miles away. Mercury has no moons that are known, and it is thought that, if any exist, they would have been discovered by photography through a telescope at a transit of this planet across the face of the Sun. Incidentally, the only planets that can transit or pass between us and the Sun's disc are those having their paths inside of the Earth's orbit, namely, Mercury and Venus.

Mercury makes the trip around the Sun in eighty-eight of our days. As Flammarion points out, a centenarian on Mercury has lived but twenty-four of our years. It is believed that Mercury always keeps the same side toward the Sun just as our Moon does toward the Earth. Therefore, it must rotate on its axis in exactly the

same time that it takes to go around the Sun.

The side of Mercury which is always turned toward the Sun is evidently very hot. By means of the thermocouple, the temperature has been measured, and it has been found to be over 600 degrees Fahrenheit, hot enough to melt lead and tin.

Mercury has the most eccentric orbit of any of the planets except Pluto and that of some of the asteroids. This large eccentricity has made it possible to make one of the astronomical tests of the Einstein Theory of Relativity in the movement of its perihelion point, that is, the point on the orbit nearest the Sun.

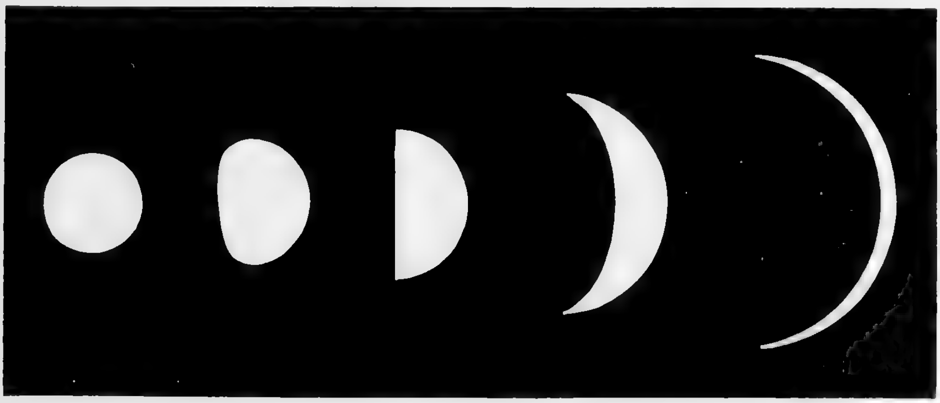
The telescope shows us that Mercury goes through all the phases that our Moon goes through, and, of course, it is for the same reason. Incidentally, the only planets that can pass through the crescent phases are those having their orbits inside that of the Earth, namely, Mercury and Venus.

Mercury is the smallest of the planets except the asteroids. Schiaparelli, the Italian astronomer, discovered some faint markings on Mercury which he thought to be permanent. Barnard described these markings as "very much resembling those seen on the moon with the naked eye." Lowell drew them more definitely as streaks. Antoniadi has confirmed Schiaparelli's work with the 32-inch refracting telescope at Meudon, near Paris. Certain permanent markings are so well known that a chart of the planet's surface has been drawn by him.

Mercury has very little atmosphere, and for this reason and also because of the high temperature on the side toward the Sun, can have no life as we know it on the Earth. According to Antoniadi, however, the atmosphere although very tenuous seems to support clouds of dust which are made visible by the temporary obscuration of the surface beneath,—that is, the darker permanent details are hidden at times by shifting dust formations.

Venus is second in order from the Sun, and for us is the brightest of the planets,—in fact, the brightest object in the sky except the Sun and the Moon. When at or near its greatest brilliancy, it can easily be seen in the daytime sky in full sunshine. In size it is very nearly equal to the Earth; in fact, Venus has been referred to as the twin-sister of the Earth.

Venus goes around the Sun in 225 of



VENUS

This shows Venus approaching the Earth. When she first comes into the evening sky she appears close to the Sun and shows nearly a full disc in the telescope. As she approaches us she appears larger and less fully illuminated, and, up to the time when she is a "half-moon," is seen farther from the direction of the Sun. Thereafter she seems to approach the Sun again, becoming meanwhile an ever larger but thinner crescent. The proportions here, however, are not drawn to scale. This illustration and description from "Splendour of the Heavens," published by Hutchinson & Co., London.

our days, and it comes closer to the Earth than any other of the major planets, approaching nearly 10,000,000 miles closer than Mars. The rotation period is not very definitely known, the evidence not being conclusive. From all the observed phenomena, the opinion reached at present is that Venus' rotation period is likely several weeks, being neither short like the Earth's, nor very long like Mercury's.

Like Mercury, Venus goes through all of the phases that our Moon goes through. The first person to see the phases of Venus was Galileo, these having been one of his earliest telescopic discoveries. According to the old Ptolemaic, or Earth-centered theory of astronomy, Venus was believed to travel around the Earth *inside* the Sun's orbit around the Earth. Since the lighted side of Venus must always be turned toward the Sun, and since Venus never traveled as far as ninety degrees away from the Sun in the sky, it is evident that it should not have exhibited any except crescent phases. But Galileo observed Venus in the gibbous phase, and this proved to be the most serious blow to the Earth-centered theory of Ptolemy. The precarious position of science in those days is indicated by the fact that Galileo announced his discovery in an anagram.

Venus has no known moons, and as in the case of Mercury, it seems probable that if there were any of considerable size, they would have been discovered at a transit of Venus.

Transits of Venus were formerly used in calculating the distance of the Earth to the Sun, the method having been first pointed out by Halley of Halley's Comet fame. These transits, however, are not of frequent occurrence,—the last was in 1882, and the next will be in the year 2004.

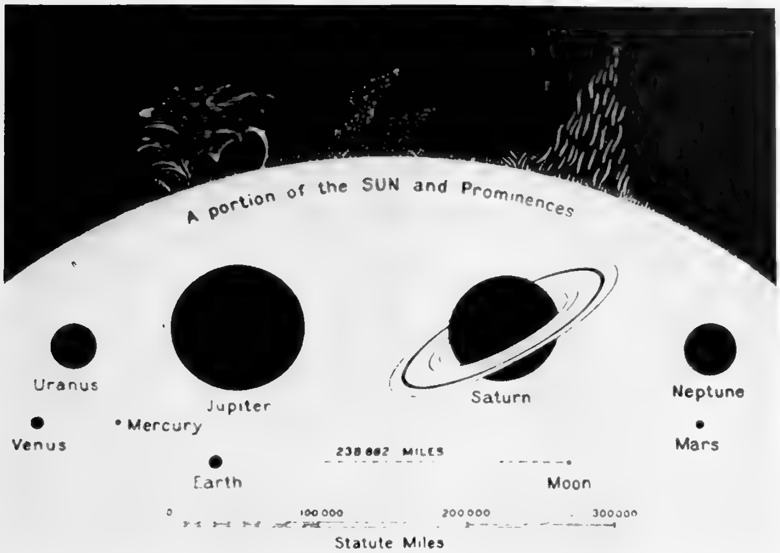
The temperature of the dark side of Venus has been found to be about 13 degrees below zero, Fahrenheit, and the bright side is only a few degrees higher. This is probably due to conditions similar to those which prevail in the Earth's stratosphere, for the measures of the temperature of Venus refer to the upper regions of its atmosphere or the upper surface of the bright envelope of cloud which surrounds this planet.

Venus is perpetually covered with a dense atmosphere, and this cloud-covered surface is responsible for the great brilliance of the planet, but it is at the same time a great drawback to terrestrial astronomers because it hides from view the detail on the surface beneath. Were it not for this heavy blanket of clouds, we should know much more about physical conditions on this interesting globe. Only a few elusive details are now and then seen in the telescope.

Although Venus has an atmosphere, it has not been possible to detect oxygen or water vapor in this atmosphere. If these exist, they must be below the outer reflecting layers. One of the recent discoveries of astronomy, however, has been that there are large quantities of carbon dioxide in the atmosphere of Venus, which fact may have some bearing on the question whether or not there is life on this planet. Both plants and animals give off carbon dioxide in the process of respiration, while green plants consume carbon dioxide in the process of photosynthesis.

Third in order from the Sun is our world, the Earth, one of the smaller planets,—four of the major planets being much larger and four being smaller. It is almost a perfect sphere, with a mean diameter of 7,920 miles. Careful measurements, however, have shown that the polar diameter is about 27 miles shorter than the equatorial diameter. This flattening at the poles, which is also noticeable in telescopic views of Jupiter and Saturn, is no doubt correlated with the origin and development of the planet.

From telescopic observation it is evident



THE SUN AND ITS SATELLITES

Chart showing the relative sizes of the Sun, Moon, and Major Planets.

that the other planets are round, and there are at least four easily observable proofs that our Earth also is round. Men and women have traveled around it by sea, by sea and land, and by air. At a lunar eclipse the shadow of the Earth on the Moon is always circular regardless of which side of the Earth is turned toward the Sun. When a ship sails away from an observer, the hull disappears first and afterwards the upper parts of the ship, the opposite effect being noticeable when a ship approaches from a distance. The appearance of the night sky changes as one travels northward or southward; for example, an observer in northern latitudes will see more and more stars come into view as he travels southward toward the equator.

The weight of the Earth in metric tons is represented by the number 6 followed by 21 cyphers. Its density is about 5½ times that of water, and this is greater than the density of the outer crust. This fact, together with the behavior of earthquake waves, as shown by the seismograph, and with the consideration of the magnetic properties of the Earth, has led many astronomers and geologists to believe that the central core is solid nickel-iron. The composition of the nickel-iron meteorites is thought by some to lend support to this theory.

Between three-fourths and four-fifths of the Earth's surface is covered with water, and the globe is surrounded by a blanket of atmosphere, shown by measurements of the Northern Lights to be nearly 600 miles thick.

The Earth rotates on its axis once in 24 hours, and this causes the daily rising and setting of the Sun, Moon, stars and other heavenly bodies. The rotation of the Earth can be proved by Foucault's Pendulum, and it is also shown by the gyro-compass. Explanation of these instruments may be found in advanced textbooks of physics or astronomy.

While the Earth is spinning on its axis once every 24 hours, it is also traveling around the Sun once every year. In its orbital motion, it is traveling about 18 miles a second,—the speed of a rifle-bullet being about one-half mile a second. The

Earth's revolution around the Sun can be proved by exact measurements of the aberration of light, the annual displacement (parallax) of the nearer stars, and the annual variation in the speed with which stars are approaching or receding from the Earth.

The Earth's axis is inclined to the plane of its orbit, being 23½ degrees from a vertical to that plane. If it were not for this inclination of the axis, there would be no shifting northward and southward of the direct rays of the Sun, and consequently no change of seasons on the Earth.

The Earth has one large satellite, the Moon, which is a little more than two thousand miles in diameter. The Moon is the nearest heavenly body to the Earth except the meteors, its average distance being about 240,000 miles. It revolves around the Earth in about four weeks and rotates on its axis in exactly the same time as that of its revolution. Its motion around the Earth from west to east causes it to rise about fifty minutes later every day. It has very little, if any, atmosphere or water. Through a telescope one sees on its surface ranges of mountains, level plains, and thousands of craters. The Moon is concerned with every eclipse, and it is the chief cause of tides on the Earth.

Next outside our Earth is Mars, the ruddy planet, which has about half the diameter of the Earth and about twice the diameter of our Moon. On account of its smaller mass, gravity on Mars is less than on the Earth. A man weighing 150 pounds on the Earth would weigh 57 pounds on Mars.

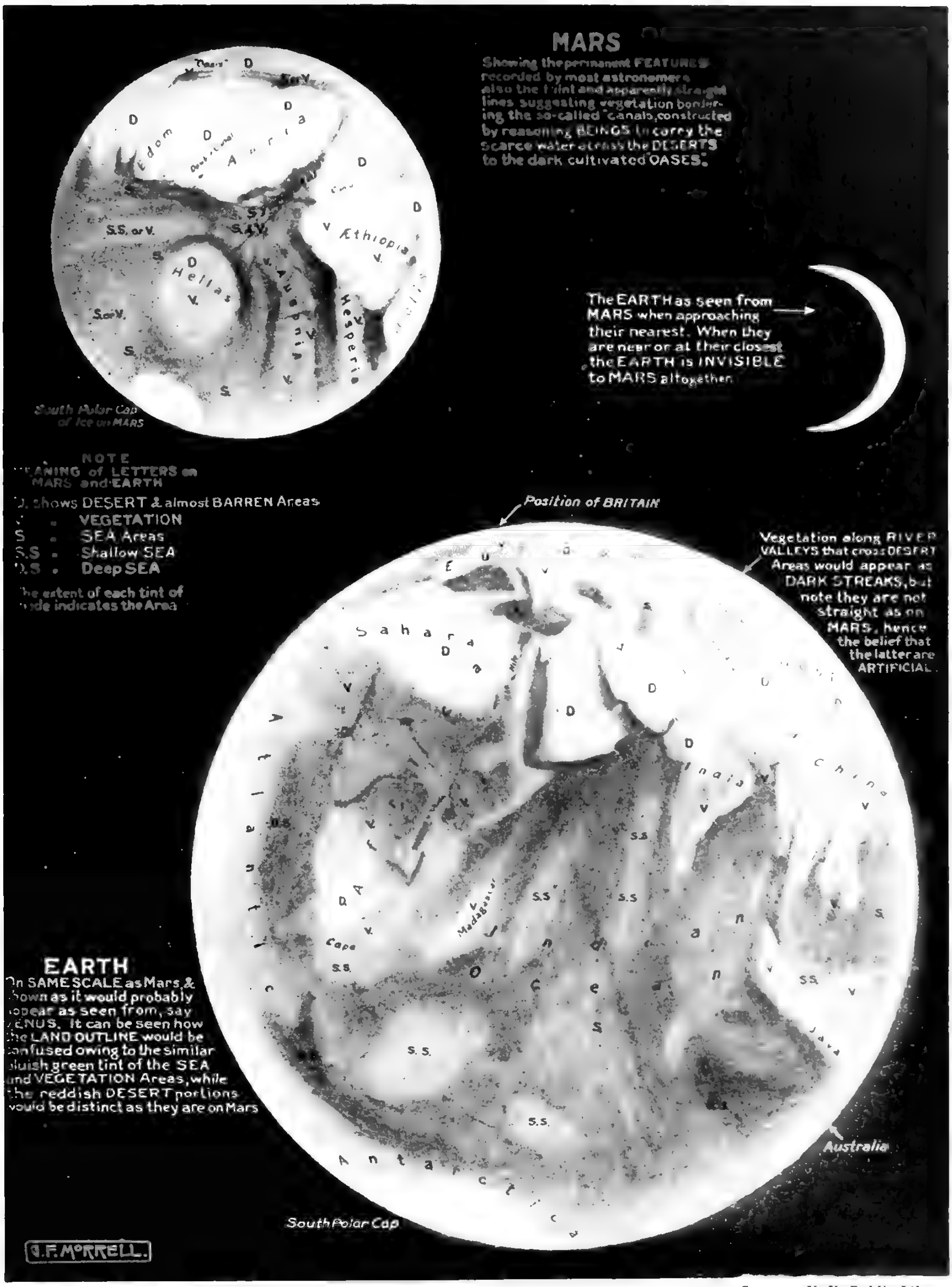
The ruddy planet revolves around the Sun in 687 of our days, the Martian year being nearly twice as long as ours. Since Mars has its orbit outside that of the Earth, it cannot go through the crescent and half-moon phases as seen from the Earth, but it does present the full and gibbous phases.

The rotation of Mars on its axis can be plainly shown by photographs through a large telescope under good conditions. Visual observations, too, are not very difficult to make for this purpose. Photographs, made as much as an hour or two apart, when compared, will furnish indisputable evidence. The large number of rotations that have occurred during the long time since Mars has been under close observation has made possible the determination of the period of rotation to within an extremely small margin of error. This investigation has shown that Mars rotates on its axis in almost exactly the same time as the Earth.

The inclination of the axis of Mars to the plane of its orbit is almost exactly the same as that of the Earth to the plane of its orbit,—probably a coincidence, as in the case of the time of rotation of the two planets.

Since Mars revolves around the Sun and since its axis is inclined to a perpendicular to its orbit, it must undergo change of seasons, as the Earth does. However, since its year is nearly twice as long as ours, each of its seasons must be nearly twice as long. Evidence of change of seasons can be seen with a large telescope under good conditions in the periodic expanding and shrinking of the polar caps (which behave in this respect like those of the Earth), and in change in color over large areas of the planet,—which may be analogous to or the same as our autumnal coloration on the Earth.

Schiaparelli, at an opposition of Mars in 1877—that is, when Mars was on the opposite side of the Earth from the sun—glimpsed markings on the ruddy planet which he called "canals." Since that time these so-called canals have given rise to much discussion among astronomers. Some astronomers virtually denied the existence of the markings, while others accepted the interpretation of Schiaparelli at full value.



Courtesy N. Y. Public Library

MARS AND EARTH COMPARED

A drawing of Mars compared with an imaginary view of the earth as it would probably appear from, say Venus. The difficulty of making out definite outlines is evident. When the Earth and Mars are closest together, the Earth would be invisible from Mars, because the unlighted or night-side of the Earth would be turned toward our ruddy neighbor. Drawing by G. F. Morrell.

Perhaps most astronomers were more or less skeptical.

Lowell and his followers believed that this intricate, geometrical network of markings could not have had a natural cause, but that it was artificial,—a system of canals dug by intelligent beings, canals to carry water from the melting ice-caps over the planet in a great irrigation enterprise. Although this is an amazing conclusion, there are a number of facts which fit in with this theory, namely: there are no mountains on Mars to interfere with these hypothetical canals, there are no oceans on Mars, there is little moisture in the atmosphere of Mars and few clouds, and with the progress of the seasons, when a polar cap began to shrink (melt), a darkening and widening of the canals (markings) was seen to progress from the polar cap over the planet.

Lowell calculated how wide these canals would have to be in order to be visible from the Earth with our largest telescopes, and he found they would have to be from ten to twenty miles wide. But Lowell did not believe that intelligent Martians had constructed a system of canals from ten to twenty miles wide extending over most of the planet. Rather he considered a canal proper too narrow to be seen from the Earth, but that what we see is a wider streak due to vegetation growing along the sides of the canal.

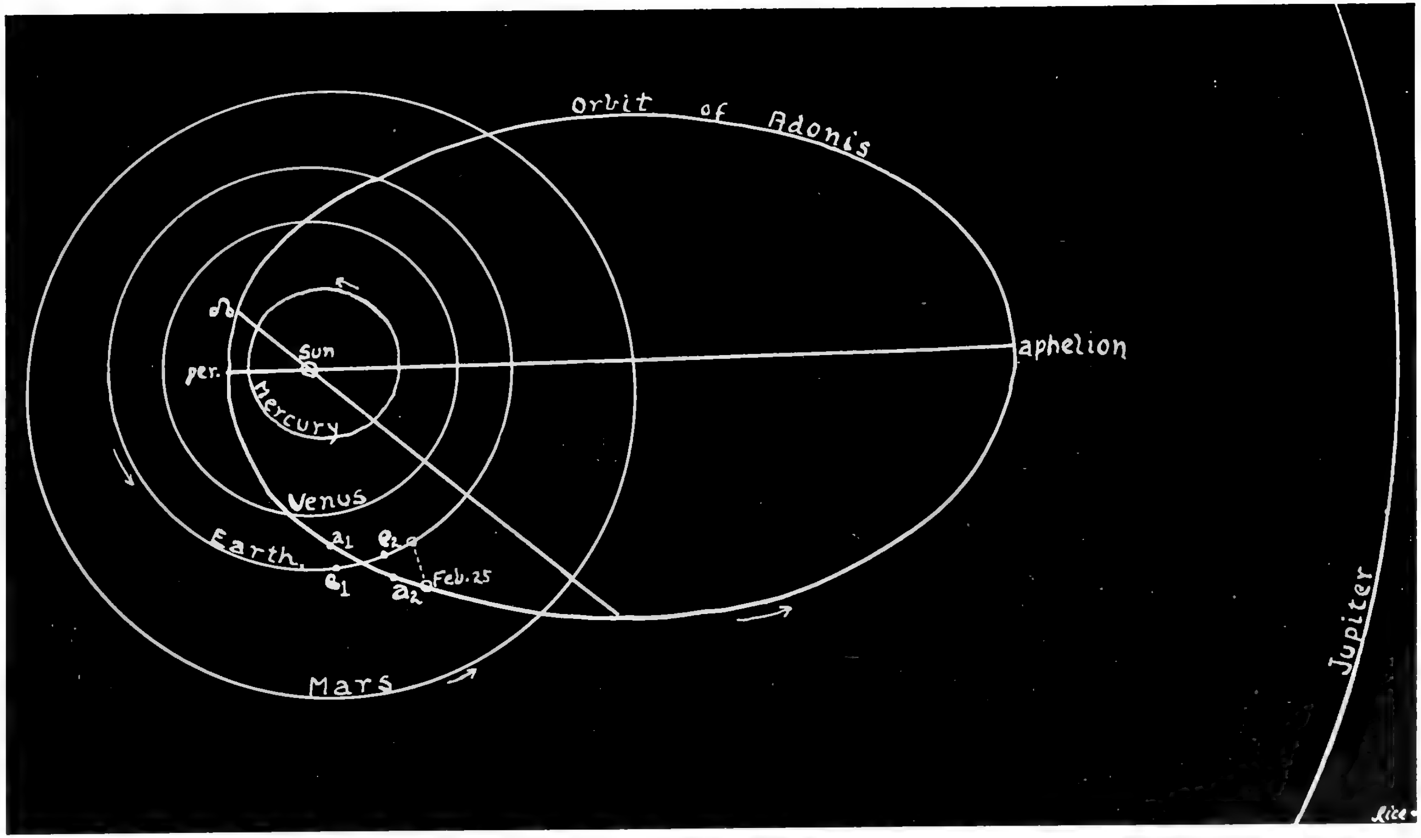
At the same favorable opposition at which Schiaparelli discovered the so-called canals of Mars (in 1877), Asaph Hall, the elder, discovered two tiny moons revolving around Mars. The discovery was made through the large 26-inch refracting telescope at the U. S. Naval Observatory. When discovered, these satellites were the smallest heavenly bodies known except the meteors. The outer one is estimated to be five miles in diameter and the inner one ten miles in diameter.

The question of perennial interest about Mars is whether or not there is life on the planet. The answer depends in part upon conditions. Without doubt, Mars has an atmosphere. By indirect spectroscopic investigation, we know this atmosphere contains both oxygen and water vapor, but both in much smaller amounts than they occur in the Earth's atmosphere. By means of the thermocouple the temperature of Mars has been carefully measured, and it has been found to be high enough to support some forms of life that we know on the Earth.

It seems now to be the consensus of opinion among astronomers that very probably there is life on Mars, at least plant life. And since plant and animal life developed together on the Earth, perhaps they have also done so on Mars.

It is of interest to reflect that we know more about Mars than we do about Venus, although the latter is a nearer neighbor. In the first place, when Mars is nearest the Earth, the bright side is turned fully toward us, while Venus has its bright side turned away from the Earth when it is nearest to us. And secondly, the atmosphere of Mars is very transparent while that of Venus is opaque.

Between the orbit of Mars and that of the next large planet outside, there have been found many bodies known as asteroids or minor planets, all of which revolve around the Sun in the same direction as the major planets. About 1400 have been catalogued, and it is estimated that there must be altogether many thousands in this zone. Ceres, the largest one, is nearly 500 miles in diameter. They range in size from Ceres down to the smallest known, Adonis, which is estimated to be less than one-half mile in diameter. In all probability there are thousands still smaller,—too small to be observed with our present equipment. Vesta, although only the third largest, is the brightest of the asteroids, and when



A PLAN VIEW OF THE ORBITS OF SEVERAL PLANETS AND THE NEWLY-DISCOVERED MINOR PLANET ADONIS

These orbits are roughly drawn to scale and the eccentricity of Mercury's orbit is seen. The cometary nature of the asteroid's orbit is also in evidence, the aphelion being a little over halfway between Mars' and Jupiter's orbits. A study of the positions of the asteroid and the Earth at the points a^1, e^1, and later a^2, e^2, show how within a few days in early 1936 the positions of the planetoid changed in direction to entirely different parts of the sky. (Diagram from Hugh S. Rice.)

nearest the Earth is sometimes visible to the unaided eye.

Although the asteroids occupy a belt outside of the orbit of Mars, the orbits of a few of them are so eccentric that they approach nearer the Earth than Mars or even nearer than Venus. The perihelion of Amor is inside the Earth's orbit, and that of Apollo is even within the orbit of Venus. Adonis, at a distance only a little more than 1,200,000 miles,—reaches its closest approach to the Sun within the orbit of Venus and near the orbit of Mercury. Hermes, discovered in 1937 by Reinmuth, comes closer to the Earth than any other known asteroid, approaching within 400,000 miles.

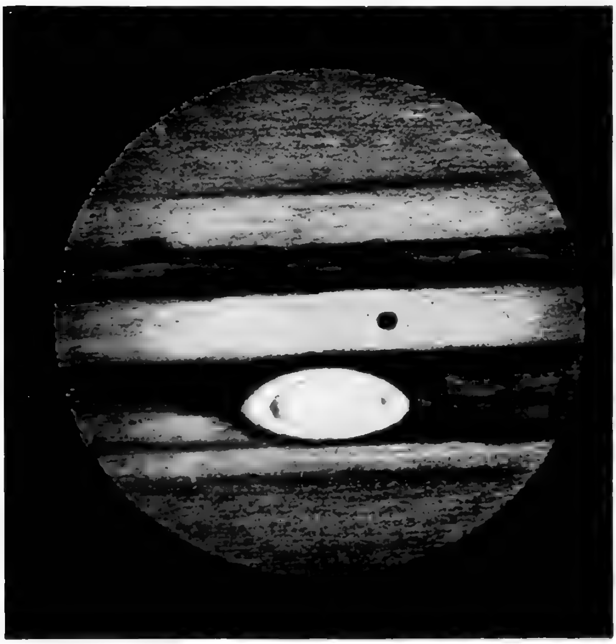
The orbit of Eros, which comes within 14,000,000 miles of the Earth, has furnished the astronomer an accurate yard-stick for calculating the distance of the Earth from the Sun.

A tiny asteroid, 5 miles in diameter, discovered by Reinmuth in 1931, has been named Riceia in honor of H. S. Rice, Associate in Astronomy in the American Museum of Natural History, in recognition of his careful studies of these interesting bodies.

Of the principal planets (that is, other than the asteroids), Jupiter is fifth in order of distance from the Sun. Being the largest member of the solar family, it has a diameter eleven times that of the Earth. In fact, it is larger than all the rest of the planets put together. The surface gravity is between two and three times as great as that on the Earth. When closest to the Earth, Jupiter is brighter than any other planet except Venus and occasionally Mars; at such times it casts perceptible shadows of terrestrial objects.

With even a small telescope, one may see distinct belts in the atmosphere of Jupiter running parallel to its equator. By observation of these belts and other markings, which are more or less permanent, it has been determined that this giant rotates on its axis in less than ten hours, the shortest period of rotation known among the planets. No doubt this rapid rotation is correlated with the very noticeable bulge at the equator and flattening at the poles, observable in a small telescope. While Jupiter rotates on its axis at this rapid speed, it takes nearly 12 of our years to revolve around the Sun.

It is quite certain that we see only an outer surface of cloud, probably clouds of solid crystals or liquid droplets of ammonia in an atmosphere of methane on this planet. Both ammonia and methane (a gas known as fire-damp when it occurs in mines) have been identified on Jupiter by indirect methods of spectroscopy. For



Courtesy of Yerkes Observatory

JUPITER

Showing cloud bands, large red spot, and shadow of one of the Galilean moons. Drawn by Barnard. May 26, 1908.

many years it has been known that Jupiter rotates faster at the equator than at higher latitudes. On this account, it was formerly believed that the planet was highly heated and plastic, but since the invention of the thermocouple, the surface temperature of Jupiter has been measured and has been found to be very low, about 200 degrees below zero, Fahrenheit. It is now believed that this difference in rotation speed is correlated with the fact that Jupiter presents only an outer surface of clouds.

In 1610 Galileo discovered four large satellites revolving around Jupiter, and these are still known as the Galilean moons. Since Galileo's day five other satellites, all quite small, have been discovered. The inner seven of these satellites revolve around Jupiter in the same direction in which the planet rotates, but the outer two revolve in the retrograde direction. It has been suggested that the outer two may be captured asteroids.

THE UNIQUE RING OF SATURN

Drawing of Saturn showing different phases with respect to its ring. (After Proctor.)

Saturn is the sixth planet in order from the Sun. It is next to Jupiter in size. To the naked eye it looks like a dull yellow first magnitude star. Because of its unique series of rings, it is considered by many persons to be the most beautiful telescopic object in the sky. Galileo's telescope was not good enough to reveal the shape of these rings, and it was not until 1655 that Huyghens perceived the true shape and position of the rings. Formerly the rings were believed to be hot, and were referred to as the fiery rings of Saturn. They were then considered as evidence in favor of the nebular theory. Recent investigation has shown that the rings are made up of myriads of tiny solid bodies or "moonlets," and of course they are very cold.

Around Saturn there are faint belts parallel to its equator. Also there are more or less temporary spots, which have made it possible to determine how long it takes Saturn to rotate on its axis, and this period is a little more than ten hours. Saturn is even more oblate than Jupiter. The period of revolution around the Sun is nearly 30 of our years. When we observe Saturn in the constellation of The Fishes (where it is in 1938) we may reflect that it will require 29½ years for the planet to travel around the sky to this place again.

The surface temperature of Saturn is nearly 240 degrees below zero, Fahrenheit. Ammonia and methane have been identified in the atmosphere of Saturn, as they have in Jupiter.

Saturn has nine satellites, eight of which revolve around the planet in the direction in which it rotates on its axis. The ninth satellite, however, revolves backward, as do the outermost two of Jupiter.

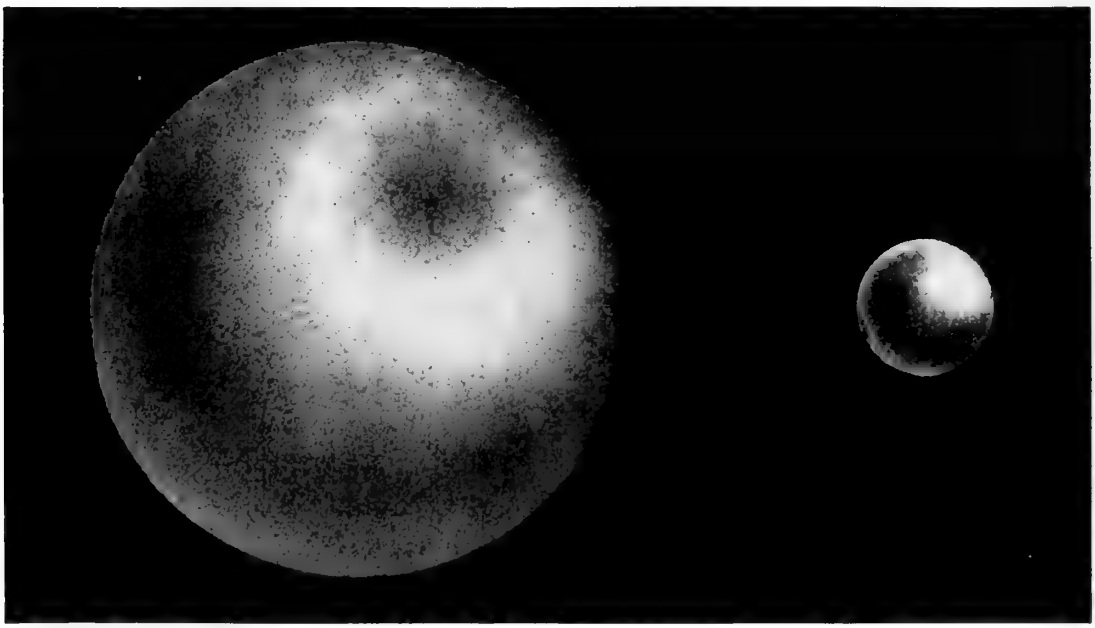
Uranus, the seventh planet from the Sun, was the first to be "discovered." It was found accidentally in 1781 by William Herschel, who at first thought it was a comet and so reported it. After it was proved to be a planet, Herschel wanted to name it "Georgium Sidus" in honor of

King George III. Many other astronomers called it "Herschel," but finally the name "Uranus," proposed by Bode, was adopted. The planet was discovered in the constellation Gemini with a 7-inch reflecting telescope made by Herschel himself. It is about sixth magnitude, and under ideal conditions is just visible to the naked eye. In color it is apple-green.

Uranus takes about 84 of our years to go once around the Sun. Its time of rotation has been determined by V. M. Slipher to be about 10¾ hours. Uranus has four satellites, which are inclined 82° to the plane of the planet's orbit, and their revolution is retrograde. The rotation of the planet on its axis seems to be in the same plane as that of the orbits of the satellites, and it is also retrograde, unless we look upon the inclination of the axis of Uranus as a little more than 90°, as it would be if measured from the other side.

The discovery of the eighth planet, Neptune, is perhaps the most dramatic achievement in the history of astronomy. The honor of discovery is shared by two young mathematical astronomers, Adams, a student of the University of Cambridge, and Leverrier of Paris. It had been found that Uranus did not follow closely its computed orbit,—in fact, it behaved as though it were influenced by an outer planet. From the observed perturbations, these two astronomers, working independently, calculated the position of the hypothetical planet. Adams finished his calculations first, but there were delays in checking up at the Greenwich Observatory. Leverrier finished his work, and sent a message to Galle at the Berlin Observatory, who found the planet in a very short time within a degree of the point indicated by Leverrier.

The planet was discovered in 1846, and it was first named "Leverrier," but this name was soon superseded by the name



URANUS AND THE EARTH

The planet Uranus is nearly four times the diameter of our Earth, but is nineteen times as far from the Sun, so it receives 360 times less light. It was the erratic behavior of Uranus that led to the discovery of the planets Neptune and Pluto. Photo from "The Splendour of the Heavens," published by Robert M. McBride and Company.

"Neptune." Its period of revolution around the Sun is about 165 of our years. Its period of rotation on its axis, determined spectroscopically, is about 16 hours, and the direction is from west to east (direct), while the revolution of its only satellite, Triton, is from east to west (retrograde)—a surprising condition.

Eighty-four years after the discovery of Neptune, a ninth major planet was added to the solar family, having been discovered photographically at the Lowell Observatory, in following a program inaugurated by the founder of this observatory. Among other things, Percival Lowell had two especial purposes in mind when he established the observatory which bears his name,—first, to study Mars, second, to search for ultra-Neptunian planets. The first object was carried out very thoroughly during his lifetime, but in the second no tangible results were obtained until after his death. However, the program of search was carried on by V. M. Slipher, who succeeded to the directorship of the observatory.

After years of search, the new planet was photographed with the 13-inch astrographic telescope, and "picked up" on the plate with the aid of the "blink-microscope," by Clyde W. Tombaugh. This was in January, 1930, but the discovery was not immediately announced. Dr. Slipher and his associates wanted to be sure about the nature of the body. It might be a comet, as William Herschel at first thought Uranus to be. If it were a comet, it would be found to be moving rapidly toward or from the Sun, unless at or near the outer end of its long elliptical orbit. It would take a little time to be sure about this point.

After some seven weeks of careful observation and computation, the Lowell Observatory astronomers became thoroughly convinced that the new body was a planet, and its discovery was announced on March 13, 1930, the birthday of Percival Lowell. Many astronomers wished to have the new planet named "Lowell," but, in view of the experience in naming Uranus and Neptune, it seems fortunate that this was not done. Instead, the Lowell Observatory astronomers decided upon the name "Pluto," the god of darkness, an appropriate name since the new planet is so distant from the Sun that it receives very little light from that central luminary.

However, it is to be noted that the symbol for the new planet, which is used by the United States Naval and other observatories, is made up of a combination of the first two letters of the name "Pluto," and that these two letters are the initials of Percival Lowell.

By measuring its movement against the background of the stars from night to night, and making the necessary allowances, it was possible to compute its period of revolution around the Sun. This period has been found to be about 248 years. Then by using Kepler's third law of planetary motion, the so-called Harmonic law, its distance from the Sun has been determined to be nearly 4,000,000,000 miles. Its relative brightness gives some clue to its size, and it is believed to be smaller than the Earth. It is yellowish in color, but it cannot be seen except through our largest telescope. It has the most eccentric orbit of all the planets. In 1989 it will be closer to the Sun than Neptune, but at that time it will not be very close to Neptune.

The first institution in the world to establish a model of the Solar System of large size in combination with a Zeiss Projection Planetarium was the famous Deutsches Museum in Munich. Its director, the late Oskar von Müller, generally considered to be the leading museum man of this generation, believed that these two instruments would supplement each other, that they were necessary to each other in making a

complete unit. The Curator of the Hayden Planetarium is indebted to Dr. von Müller for this idea, and the experience of more than two years has convinced us of the correctness of his conclusion.

This model of the Solar System is known as a Copernican Planetarium, so called because it shows the planets and the central Sun according to the Copernican system of astronomy, which system is now universally accepted. It was designed and built by J. W. Fecker of Pittsburgh.

With this three-dimensional apparatus, capable of simulating the motions of the real heavenly bodies, the observer is on the outside looking on, as it were,—and it is evident that he can get a clear and adequate idea of the working of the Solar System in a few minutes. We believe that a short time spent with this model in the large circular room on the first floor of the Planetarium building will make the demonstration with the Zeiss Projection Planetarium in the dome on the floor above more understandable and more enjoyable.

REFERENCES:

Henry Norris Russell, *The Solar System and Its Origin* (Macmillan, 1935)

Thomas Crowder Chamberlin, *Two Solar Families* (University of Chicago Press, 1928)

Forest Ray Moulton, *An Introduction to Astronomy* (Macmillan, 1916)

Sir James Jeans, *The Universe Around Us* (Macmillan, 1929)

MASKS

CLARK WISSLER

A DEVIL DANCER

In Tibet the Devil Dancers appear at the end of the year, impersonating the gods who expel the demons of bad luck. The dancer represented here wears the mask of Marbo, one of the three attendants of the Lord of Hell.

MASKS

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MASKS

By CLARK WISSLER

THE USE of "false faces," or masks, is an old trick of the human race. The museum visitor, viewing the weird and often grotesque masks on exhibition, may be moved to speculate as to the meaning of these caricatures and to wonder why so much space is allotted them. For example, an exhibit concerning the Iroquois Indians of New York is certain to contain a number of curious masks, because these Indians maintain a unique society for men known to us as the False Face Society. This name calls attention to the most striking outward feature of this society, the wearing of masks.

There is something impressive in Iroquois "false faces," as many museum visitors have testified; they have a striking individuality, especially in the treatment of the eyes and the mouth. Carved upon the trunks of living trees, depicting a face with cavernous eye holes, strong nose, and protruding lips, the face framed in with long hair falling loosely from a wig: such images peering from the shadows of the open fire, around which Indians love to gather, impress themselves too deeply upon the mind to be forgotten. Those of our readers who saw the play "Hiawatha," as presented some years ago, or the film made from it, will recall the striking entry of the False Face dancers, their slouching gait, and above all, their strange, awful mien. (Figs. 1-3)

But the Iroquois are not the only Indians who use masks; on the contrary, the practice is widespread. The totem-pole makers of Alaska and Vancouver Island also are celebrated for their wooden masks, which far excel in variety and size those of the Iroquois. Visitors to museum collections may note these wooden masks, painted in black, red, and green, especially a few huge masks, seemingly too large and heavy for one person to support.

The masks of the Iroquois represent faces essentially human, whereas these larger masks of the totem-pole makers depict animal and bird monsters. Not infrequently the jaws of these masks are hinged so that the dancers can open and close them at will, and often when the mouth of the mask is opened in this way, a human face appears within. This is not, however, altogether a matter of fancy for throughout the myths of primitive folk runs the idea that those who have power can change at will from human to animal form and back again. (Figs. 44-48)

Thus the frequent reader of Indian tales is familiar with such incidents as "Now a raven appeared and spoke to him, but as

Fig. 1—Iroquois mask, made of cornhusks.

Fig. 2—Iroquois mask of wood.

According to the Iroquois belief, these masks represent spirits or supernatural beings which have power to frighten away evil and disease. Thus when they enter the village or a house they are believed to make it a safe place to live in.

Fig. 3—IROQUOIS FALSE FACE SOCIETY, ENTERING THE DANCE LODGE

Fig. 4—A clay head, a prehistoric example of modeling from Vera Cruz, Mexico.

the raven came nearer, it became a person standing there." Certain large wooden masks of the Indians of Vancouver Island are so constructed that the dancers are able to demonstrate such a supernatural transformation of the mythical raven into a person; the outward forms of these masks represent the raven, but when concealed cords are pulled by the wearer, the raven face of the mask opens, and that of a human appears inside. Few peoples have carried this idea out so ingeniously in the construction of their masks as have these wood-carving Indians of Alaska and the Canadian Coast.

J. G. Swan, one of the early visitors to these Indians, writing as an eyewitness, says,

. . . The masks are made of alder, maple, and cottonwood; some are very ingeniously executed, having the eyes and lower jaw movable. By means of a string the performer can make the eyes roll about, and the jaws gnash together with a fearful clatter. As these masks are kept strictly concealed until the time of the performances, and as they are generally produced at night, they are viewed with awe by the spectators; and certainly the scene in one of these lodges, dimly lighted by the fires which show the faces of the assembled spectators and illuminate the performers, presents a most weird and savage spectacle when the masked dancers issue forth from behind a screen of mats, and go through their barbarous pantomimes. The Indians themselves, even accustomed as they are to masks, feel very much afraid of them, and a white man, viewing the scene for the first time, can only liken it to a carnival of demons.

However, it was not alone the totem-pole-carving Indians of Vancouver Island and Alaska who indulged in such impressive and picturesque pastimes, for the Aztec of Mexico, their predecessors, and the prehistoric Maya of Yucatan seemed

Fig. 5—Mask from Tibet, representing a cow.

Fig. 6—A Chinese mask.

to have specialized in masks. (Figs. 53, 54 and 57) The former have left behind a number of curious manuscripts in picture writing, showing gods and heroes wearing masks. The Maya were expert carvers in stone, covering their temple walls and stone monuments with carvings in low relief, among which may now and then be seen masked figures. (Fig. 52) Nor was it only among the peoples of the Americas that such masks were used; they were used in the Old World as well. In present-day China, India, Java, etc., one meets with processions and festivals in which masked figures play the chief rôle, for the most part survivals of ancient customs. (Figs. 55-56)

Often when observing a custom so widespread as the use of masks, the thought arises that here is something of special importance in the

Fig. 7—In Tibet, the owl is regarded as a spy and so we have this interesting mask.

Fig. 8—A Japanese actor wearing a mask representing a mythological character, spoken of as the "Wanderer."

Fig. 9—The old "Woman of the Mountain." A Japanese character frequently seen in the theatre.

Fig. 10—A Japanese mask worn by actors to represent a mythological bandit. The full stage costume of the actor is shown above.

Fig. 11—A small clay figurine from Libertad, Chiapas, Mexico.

life of man, and a custom whose beginning dates back to the dawn of civilization. At any rate, a custom that appears to be world-wide and ancient seems to be worthy of serious study.

Turning again to the Iroquois Indian False Face Society, we note that there are in this company at least four classes of false faces: doorkeeper faces, those worn by doctors when treating the sick, the beggar masks, and what are spoken of as secret masks. Many individual masks have names according to the mythical being they represent, usually certain stone giants that play a large rôle in the beliefs of these Indians; one of the myths accounting for the origin of the Go-gon-sa false face was recorded by Mrs. Harriet Maxwell Converse as follows:

It could see behind the stars. It could create storms, and summon the sunshine. It empowered battles or weakened the

Fig. 12—This is an impressive face showing unusual skill on the part of the carver. Lips drawn back, the hostile eye, and the protruding beak, all combine to give a ferocious look. Indians of British Columbia.

Fig. 13

Fig. 14

JAVANESE FESTIVAL MASKS

The Javanese are skilful mask makers. Their masks are expressive, and usually elaborately painted. They are favorites of collectors, many persons having built up large private collections, probably because Javanese mask makers look upon their work as art rather than as magic and religion. The prevailing colors are red, black, orange, gold, and white.

Fig. 15

The Bella Coola Indians, British Columbia, carried the making of masks to an extreme. Wood was the chief material so the masks were, in part, an expression of art in wood carving. Skilful painting emphasized the facial features. As usual with primitive mask makers, the forms were standardized because each represented a mythical being, with a name and individual characteristics, known to most members of the tribe.

Fig. 16

forces at will. It knew the remedy for each disease, and could overpower Death. It knew all the poison roots and could repel their strong evils. Its power was life, its peace the o-yank-wah, the tobacco which drowsed to rest. The venomous reptiles knew its threat and crept from its path. It would lead the young hunter back to his people when the Stone Giant directed. It said: My tree, the basswood, is soft, and will transform for the molder. My tree wood is porous, and the sunlight can enter its darkness. The wind voice can whisper to its silence and it will hear. My tree wood is the life of the Go-gon-sa. Of all in the forest there is none other.'

With this knowledge, the young hunter started on his way carving go-gon-sa-so-oh, (false faces). From the basswood he hewed them. By the voice of the Stone Giant he was guided to choose; and well he learned the voices of all the forest trees before he completed his task.

In his travels he met many strange animals and birds, which he detained until he had carved them in the basswood; and inviting them to tarry, learned their language and habits; and though fearing the Giant's reproval, for he constantly heard his voice encouraging or blaming, he learned to love these descendants of his ancestors, and was loath to leave them when compelled to return to his home.

Many years had passed in the laborious task, and he who entered the cave a youth, had become a bent old man when, burdened with the go-gon-sas he had carved, he set out on his return to his people. Year after year his burden had grown heavier, but his back broadened in strength, and he had become a giant in stature when he reached his home and related his story. (Figs. 1-3)

In a general study of masks, the first questions to arise are, "What place do masks hold in the interest of primitive peoples? What kind of ideas and beliefs are associated with them?"

If we begin with our own civilization and time, we see the mask as a frivolous object; the clown or the silly buffoon may use it to heighten his grotesqueness; children and young people may use masks on fête days to amuse adults and to frighten the timid. Occasionally they are still used upon the stage when some of our ancestral folklore is to be enacted. (Fig. 35)

Fig. 17—A mask from Java.

Fig. 18–A masked figure representing the mystic serpent in Japanese mythology.

Fig. 19—A Japanese stage mask representing a male demon.

Fig. 20—Japanese mask representing the jolly woman.

Fig. 21—Representing a female demon.

Fig. 22—Representing a mythological character, known as the whistler.

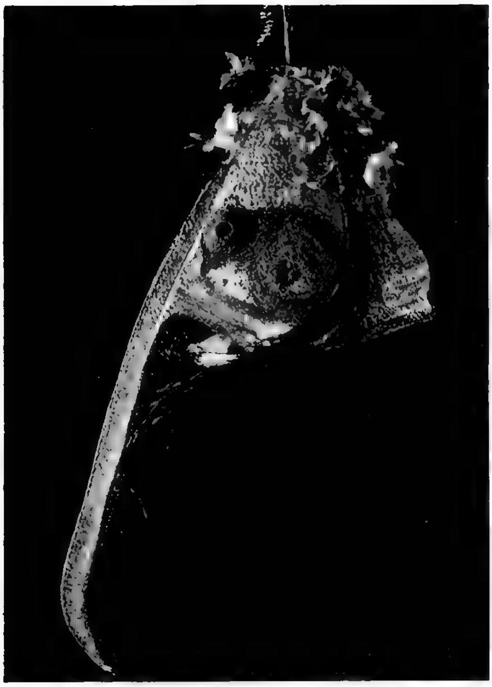

Fig. 23–A long-nosed mask from the Sepik River people of New Guinea who regard such noses as a mark of beauty.

Fig. 24–Many New Guinea masks are overlaid with shell; often the design is sufficiently delicate to produce an unusually beautiful type of mask.

Fig. 25–This large wooden mask from New Guinea is of the type used as a gable decoration to a house.

Fig. 26–A mask of plaited materials.

NEW GUINEA MASKS

Fig. 27

Fig. 28

Fig. 29

Fig. 30

A GROUP OF AFRICAN MASKS

Fig. 31—Plains Indian Dog Dancer, drawn by Bodmer. This is not a masked figure but calls attention to the common New World practice of massive head and face costume, with the face of the wearer exposed, but modified by painting.

Yet, on the whole, the mask is to us something childish, something scarcely to be considered respectable. Consequently, when we stand before a museum case, or look over the pictures in a book, we are puzzled how to justify the attention given to the subject of masks by serious-minded people; we may go even further and assume that the people who made and used these masks were infantile in their interests, so far benighted as to be beyond understanding. This is in keeping with one of our bad intellectual habits, viz., attributing our own ways of thinking to the savage mind. Because we put no value upon masks, tolerating them only in light, frivolous associations, we fail to see how savages could regard them otherwise, even such savages of ancient Europe as were our ancestors.

When seriously used, masks are part of the regalia worn in savage ceremonies, chiefly religious. (Figs. 31-33) Such ceremonies may have many features, but most of them possess regalia and a ritual in which are songs and dances. Here, again, we often misjudge the savage, for to us a dance is anything but religious, and so his dancing upon such occasions, if it does

Fig. 32—A Kachina Dancer. The tourist in New Mexico and Arizona is offered many appealing small wooden images or dolls, called Kachinas. Each of these has a name, the name of the supernatural being it represents. In the regular Kachina ceremonies of certain Pueblo Indians, men and women wear masks to impersonate these gods. Among the Hopi the number of such gods, or Kachinas, exceeds 150. The colors are usually green, white, black, red, and blue.

Fig. 33–TWO MASK CEREMONIES OF THE NAVAHO INDIANS
At the left a man masked to represent a god is driving out disease by shaking his rattle over the patient, while the naked youth at the right is a novice undergoing an initiation rite.

Fig. 34–PUEBLO INDIAN ALTAR SHOWING REPLICA OF MASKED DANCERS, IMPERSONATING GODS

Fig. 35—A CHRISTMAS-TIME SCENE IN ENGLAND
Apparently the survival of an old pagan festival in which dancers appear, wearing masks.

Fig. 36—TOTEM POLES IN FRONT OF AN INDIAN HOUSE, SOUTHERN ALASKA
The large faces carved on these poles are in the same style as wooden masks used by the same Indians.

Fig. 37—A MASK AND HEADDRESS
Swan's down, eagle tail feathers, and human hair are skilfully arranged on a wooden frame attached to the mask, which represents a dying man, with open mouth and protruding tongue. This mask was worn by a doctor during healing ceremonies. Northwest Coast Indians.

Fig. 38—FACE OF A BEAVER ON A BOX
While this is not a mask, the method and quality of the caricature are similar to that found in masks. Northwest Coast Indians.

Fig. 39
A mask from New Ireland, neatly carved of wood. It is never safe to guess the functions of masks; thus in this little Island world they are worn in ceremonies to commemorate the dead.

Fig. 40
This jolly face illustrates the spirit of masked dancing among the Eskimo and the Indians of Alaska.

Fig. 41
A ceremonial mask from New Ireland.

Fig. 42

Fig. 43

The native people of Africa, many of them expert wood carvers, emphasize the human in their masks, though caricature is evident. Some are decorated with cowrie shells, but for the most part the artist depended upon the carving technique to produce the desired effect. Incidentally we note that among primitive peoples in all parts of the world, wood is the preferred material for masks; it is only among the more complex civilizations that plastic materials are used.

 

Fig. 44 *Fig.* 45

TWO VIEWS OF A BELLA COOLA MASK

The Indians of British Columbia and Alaska delight in masks which are double or triple, as the case may be. First, as in *Fig.* 46, we see what seems to be the face of a fish, but when strings are pulled this face suddenly opens and reveals a human head.

not shock us, at least provokes pity for his lack of understanding. On the other hand, anthropologists who specialize in the study of primitive life, find in the regalia, songs, and dances what they regard as important data for the understanding of human life. (Figs. 18-26,34,36)

If the reader goes to a library and asks for special publications upon the American Indian, for example, long detailed studies of ceremonies will be given to him, describing minutely just how the participants were dressed, what they did, sang, and danced; further, an attempt will be made to explain the meaning of the ceremony. Any reference librarian can give a long list of such books, which means that many tribal ceremonies have been studied in every part of the world—Asia, South America, Australia, Africa, and elsewhere—and looking over these detailed descriptions of savage ceremonies, one finds them much alike. (Figs. 3,31,33,35,62)

No matter to what part of the world we turn, we find the belief that these ceremonies, songs, and dances were not designed by man, but were given to him ready made and in some mysterious fashion, just as in the case of the Iroquois Indian who started the False Face Society.

Fig. 46—A three-in-one mask from Vancouver Island: first, it appears as a large fish, but when the jaws of the fish open, we see the face and bill of a bird; finally, when these open, we see the face of a man.

Fig. 47—A double mask from the Haida Indians.

Fig. 48—A double mask from the Indians of British Columbia.

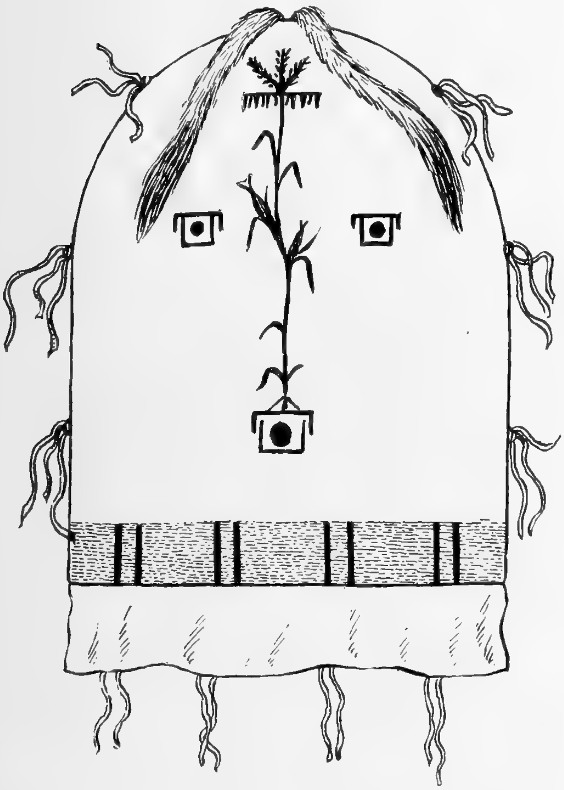

Fig. 49—A MASK USED IN THE NAVAHO NIGHT CHANT

It is a buckskin cap covering the head and face. A sacred corn stalk is represented as growing from the mouth of the wearer; the hair on the top is yellow.

(Fig. 3) Someone, at some time—usually in the good old times now passed—met a supernatural being who taught him the whole ceremony.

For example, an interesting Indian tale recounts the experiences of a young man who wandered out alone. Coming at last to a place where the beavers had a dam and their houses in the water, he sat down to meditate. These beavers, he thought to himself, must possess some extraordinary power to do as they do, and so he resolved to sleep there, hoping that the chief of the beaver might take pity on him and help him to attain to a place of power and respect among his own people. That night a beaver appeared before him, turned into a person, and invited him to follow; they passed down into the water and into the house of the beaver. It was a great lodge and his guide was the chief of all the beaver. Here the young man saw many beaver and here he stayed throughout the winter as the

Fig. 50—A gold figure representing a masked Tiger Knight. Monte Alban, Oaxaca, Mexico.

guest of the beaver. When spring came, however, the young man expressed a wish to return to his people. So the beaver called into his lodge all the head beaver and, becoming like people, they performed a ceremony, teaching the young man the songs, dances, etc. Then he was conducted to the dry ground, to his old camping place, and so returned to his people, where he started the ceremony he learned from the beaver.

When we review this tale, we note, first, that there appeared to the Indian a beaver which took on human qualities, because it spoke to the Indian and conferred upon him powers and imparted information, and so the Indian started a ceremony. But what is this ceremony like? It begins with a narrative like the preceding; then the leader of the ceremony takes the part of the beaver, other participants are the beaver's helpers and, finally, one person takes the place of the original hero, who is said to have been received into their lodge by the beavers. The ritual which follows is supposed to repeat the events, step by step, by which the beaver conferred this ritual upon the first Indian. In other words, the incident is staged with an appropriate cast and the participants become, in a way, players presenting a drama.

This not only applies to this particular ritual, but is well-nigh universal among mankind, primitive and civilized. Naturally rituals and symbolic procedures believed to have originated with mythical beings cannot well be demonstrated except through the impersonation of these mythical beings who, as we have stated, while often conceived of as animals or birds, are also human, having a kind of alternating personality, exceeding the power of real human beings as well as animals in that they can change their bodily forms and do other things impossible for either animals or humans.

Fig. 51—A mask of gold representing the god, Xipe-Totec. Found in a tomb at Monte Alban, Oaxaca, Mexico. This is probably one of the most beautiful examples of prehistoric American art.

The wearing of a mask is the usual method of impersonating these mythical human beings or their animal counterparts. When the American Indian impersonates the buffalo, he may put the skin of the head over his own head, and look out through the eye holes; the effect may be heightened by having the whole skin fall over the shoulders of the wearer and down the back, the characteristic buffalo tail dangling below. Also the bear plays a part in the mythologies of many peoples and so is impersonated with great frequency; sometimes the face of the bear is realistically carved in wood, to which the skin of a bear is attached; drawing this over his head, the savage will crouch and growl, and by skilful acting give a satisfactory representation of a bear.

A spirited description of a masked Indian dance is given by George Catlin, the famous Indian traveler:

> My ears have been almost continually ringing since I came here, with the din of yelping and beating of the drums; but I have for several days been peculiarly engrossed, and my senses almost confounded with the stamping, and grunting, and bellowing of the buffalo dance. . . .
>
> Every man in the Mandan village is obliged by a village regulation to keep the mask of the buffalo hanging on a post at the head of his bed, which he can use on his head whenever he is called upon by the chiefs to dance for the coming of buffaloes. The mask is put over the head, and generally has a strip of the skin hanging to it, of the whole length of the animal, with the tail attached to it, which, passing down over the back of the dancer, is dragging on the ground. When

Fig. 52—A Maya carving in low relief depicting a man wearing a mask and a magnificent headdress. Many Maya carvings are so skilfully executed that one can see the mouth and eyes of the wearer through the mask. This carving is from Seibal, Guatemala.

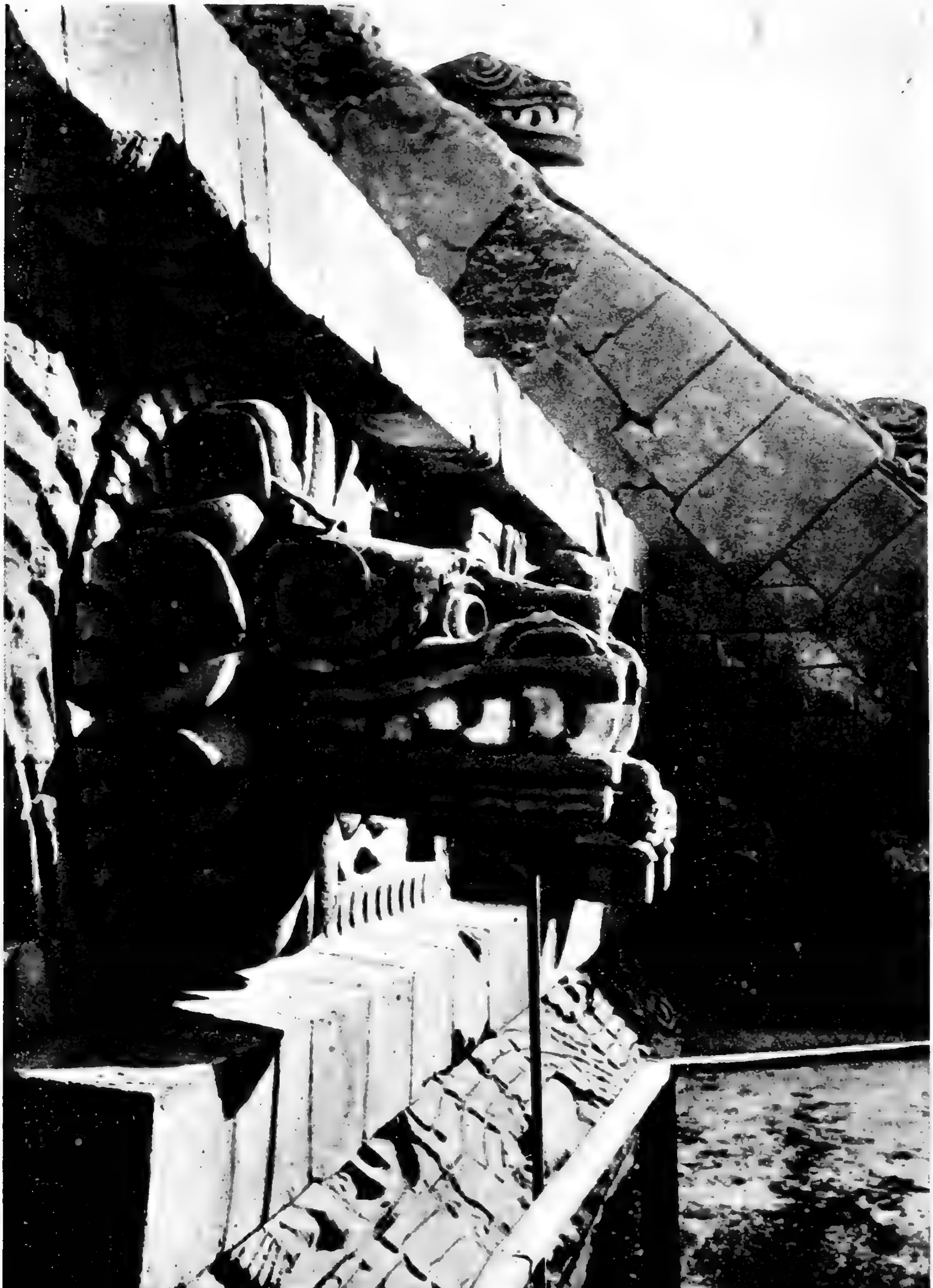

Fig. 53—A stone carving on the ruined temple of Quetzalcoatl, Teotihuacan, Mexico, representing the Feathered Serpent.

Fig. 54—Many ancient Mexican clay vessels are modeled to represent priests officiating in masks, thereby impersonating the gods.

one becomes fatigued of the exercise, he signifies it by bending quite forward, and sinking his body toward the ground; when another draws a bow upon him and hits him with a blunt arrow, and he falls like a buffalo—is seized by the by-standers, who drag him out of the ring by the heels, brandishing their knives about him; and having gone through the motions of skinning and cutting him up, they let him off, and his place is at once supplied by another, who dances into the ring with his mask on; and by this taking of places, the scene is easily kept up night and day.

That dancing with an animal mask is an old, old

Fig. 55—Two devil dancers wearing characteristic masks. Each mask is standardized as to features and represents a particular evil spirit of which there are a large number in Tibetan mythology.

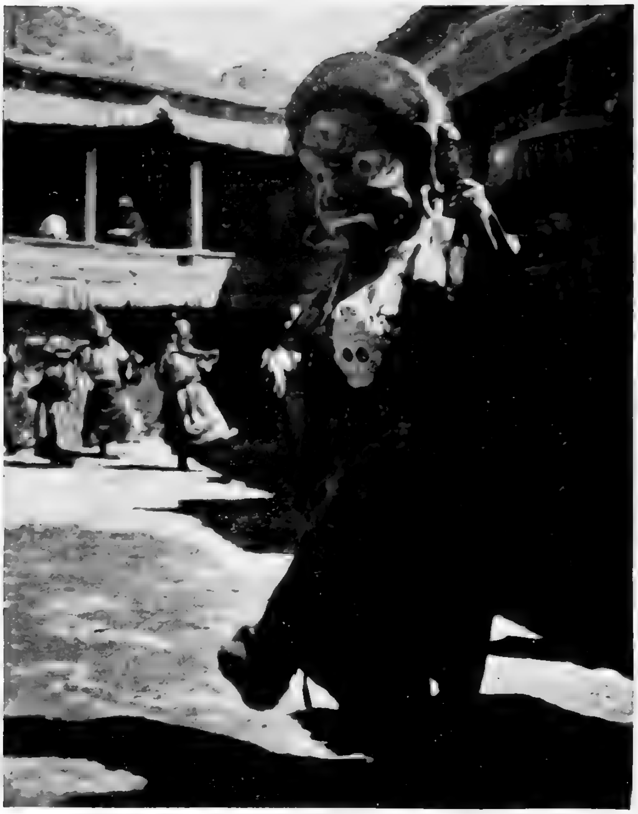

Fig. 56—A dancing, masked figure—Tibet.

stooping, are all conceived to be representative of the leading animal or hero. A particularly forcible illustration of this is to be seen in the Eagle Dance of our Southwestern Indians as, covered with down like an eaglet and with rows of feathers down the arms and a tuft for a tail, the dancers, in stooping position, simulate the soaring of the eagle.

Assuming that these masks originally developed from a simple beginning, we may properly ask as to the nature of that simple first step. However, while everyone is interested in the origins of human customs, such origins are so elusive that many serious-minded students of the subject are inclined to doubt the possibility of finding them. Thus it has been proposed that masks were first the heads of animals; again, a device for frightening children, an outgrowth of designs upon shields, painted designs upon the face, etc. All of these guesses are plausible, but as no record of the beginnings of the mask have come down to us, there seems little hope of finding the truth about the matter. We can, however, conclude that it is an old custom, known in some form to most peoples.

custom is shown by certain Stone Age pictures upon the walls of caves in France. One of these shows a dancer wearing the skin and head of a deer, while in another cave are three dancers in a row, with heads and skins of chamois, or similar animals. These last seem to be dancing by jumping up and down, holding the feet together, as do the native women in Australia when imitating the kangaroo.

As a rule, the steps in these dances are simple, but body movements are emphasized. The dancer is not merely enjoying the rhythm and excitement of the procedure, but may well be dancing as the impersonator of the animal or hero figuring in the ritual of the occasion. The swaying movements, the strutting and the

Yet, though we may never be sure of how masks came to be so widely used, it is not difficult to see that they offer a medium for art expression. We have referred to the Indians of Alaska, experienced carvers of wood, who have produced a number of masterpieces, many of which, though usually grotesque, are highly real-

istic. But for richness in conception and wealth of detail nothing seems to surpass the turquoise mosaic masks of the Aztec, in which the whole surface of the wooden mask base is overlaid with designs built up from minute bits of turquoise and other colored materials. That the earlier Maya used equally fine masks is shown by their low relief sculptures in which warriors and priests stand forth in masks and plumes. (Fig. 52) Not infrequently the sculptor, in presenting a profile, shows the face of the wearer behind the mask. If the reader imagines the great ruined Aztec temples, topping pyramids in their original grandeur, with highly decorative serpent columns, with brilliant wall paintings representing processions of plumed warriors and priests, and then in imagination tries to see the priests officiating at the altar, wearing masks encrusted with turquoise and topped by rich plumes, he will have some idea of the artistic heights to which the mask and the staging of rituals were carried in prehistoric America.

Fig. 57—A pottery vessel from Mexico, which apparently represents a large mask headdress.

If we turn to the Old World, the paintings upon the walls of temples and tombs in Egypt present priests masked to represent the gods of that religion; further, the temples of India and China present many masked images. (Fig. 55) The reader interested in the artistic aspect of masks and their relation to the theater should look up that interesting book by Kenneth MacGowan, *Masks and Demons*, in which are many good illustrations of masks, with descriptive notes.

Turning now to more prosaic problems in the use of masks by the aboriginal

Fig. 58–PORTRAIT MASK IN STONE. VERA CRUZ, MEXICO

Indian population, some curious facts in their geographical distribution are noted. Among the Indians east of the Mississippi River and near Hudson Bay, the Iroquois were not the only ones who specialized in masks. Some use of them was made by the Cherokee, Delaware, Nanticoke, Ojibway, and Choctaw, and probably many others. West of the Mississippi, among the Indians of the Plains, the heads of the buffalo, the bear, and other animals were sometimes worn in appropriate ceremonies, but carved masks have not been reported. (Fig. 60)

On the other hand, the western belt of high land from the Arctic to Panama is conspicuous for the use of masks. As we have stated, the practice was highly developed in Mexico and Central America, and again among the Indians of lower Alaska and the coast down to the Columbia River. Even the Eskimo of Alaska, and as far east as Hudson Bay, made use of masks. (Fig. 40)

Turning back to California, we find almost no masks, but among the Indians of Arizona and New Mexico again the custom comes to the fore, the best known masks being those worn in the kachina ceremonies. (Fig. 32)

In South America, there were several highly developed civilizations in the Andean highlands, the best known being that of the Inca in Peru. There is good reason to believe that the Peruvians used masks, but these do not occur in collections; nevertheless, upon pottery, and occasionally in textiles, we observe what are certainly masks, some elaborate and some grotesque. The descendants of the Peruvians even now appear on certain Christian festival days in masquerade costumes that seem to be pagan. Of special interest, however, is the placing of masks upon the faces of the dead, not only in Peru, but in the whole of the Andean highland region from the Isthmus of Panama to northern Chile. Museum visitors are no doubt familiar with the mummy bundles from Peru, with their quaint wooden and woven faces.

Leaving the Andean highlands and turning to the lowlands of Brazil, we meet with many reports of masked dancers. The shapes are usually those of the jaguar, alligator, tapir, birds, insects, etc. In some

Fig. 59–A masked dancer from Vancouver Island, British Columbia.

Fig. 60—The Assiniboin Indians still practise a ceremony known as the Fools' Dance. As may be expected, those who take part in this ceremony are given to clownish antics. One of the masks used in this dance is shown here. These masks are made of cloth.

cases wooden masks are used, but usually they are of bark, are kept out of sight of women and children and, after the ceremony, are carefully burned. While data for many tribes in the lowlands of South America are lacking, yet, from what we have, it appears that dancing masks occur from Tierra del Fuego on the south to the Orinoco River on the north, but are infrequent in several parts of Argentine and Brazil.

It is difficult to summarize this distribution in a sentence, but the intensive use of masks is more frequent in the western highlands of the two Americas than in other sections.

The most elaborate and also the most artistic masks were, as may be expected, among the old native civilization of Peru in South America and of the Maya and the later Aztec in Mexico and Central America. Among the simplest and crudest were those of the Eskimo of the far north and of the Ona near Cape Horn at the lower end of South America. Thus, the Ona usually cover the head and face with a piece of rawhide upon which are painted a few spots in color to symbolize the spirit represented. One particular mask of this kind, according to the descriptions of observers, bore red and white spots, the emblem of the god of the heavens. Shifting to the far north the Eskimo around Hudson Bay use a few simple masks of skin, rather loosely fitted to the face and bearing simple markings.

We mention these outlying examples to emphasize the wide distribution of the masking idea. Also, wherever used, the mask is intended to represent a spirit, or a supernatural being, and is thus an aid to the impersonation of these mythological personages. The primary association of the mask is therefore with serious religious practices, rather than with entertainment and esthetic effects, suggesting that the masked dances and stage effects of civilized peoples also have a serious religious background.

In conclusion it appears that in human society it is the face that is important since there one reads the tensions and relaxations which reveal something of the motives and feelings within. Persons are distinguished by their faces chiefly, and it is upon the head and face that most of the efforts at make-up are centered. It is not strange

then that when primitive man wanted to pose as a god, he made a mask to show how tradition pictured that person; if a demon was to be represented an appropriate mask was constructed, etc., the mere wearing of which was sufficient to transform the human into the super-human. As masks were usually standardized the onlookers knew at once what personality was meant. This is the principle of certain ancient oriental theatres in which the actors changed their parts by taking up another mask, thus the audience was given a cue to the change of personalities.

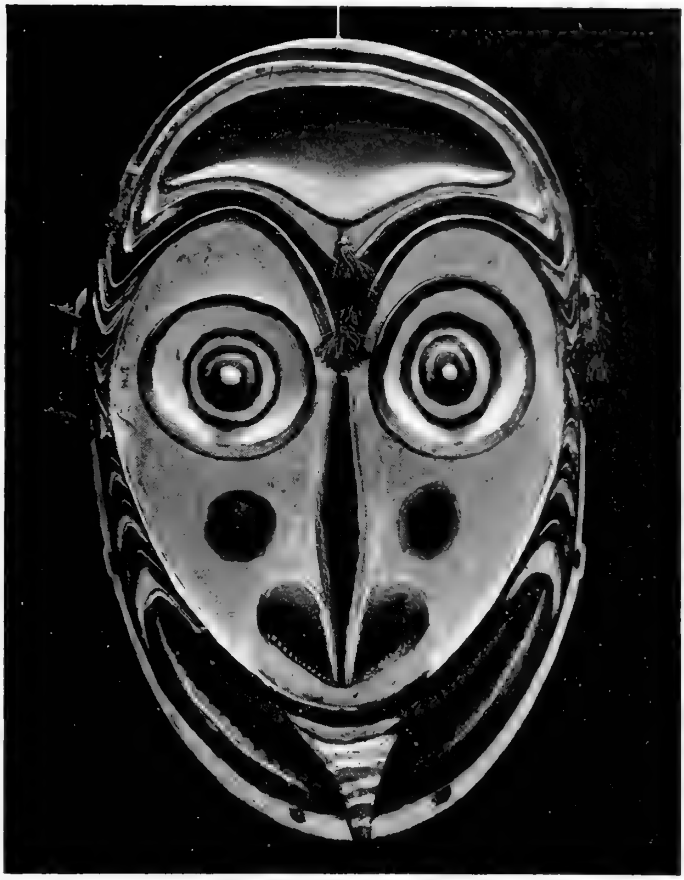

Fig. 61—Masks of this kind are used in New Guinea as gable decorations on houses. They range from a foot to four feet in height and usually are mounted in pairs, one for each gable. They are brightly painted in red, white, and black and stand out vividly against the thatch of the roof.

The earliest known masks are shown in certain paleolithic cave paintings which are mute but effective witnesses to the knowledge and use of masks in that remote period of human evolution. Yet, since that time, how little we have changed! This very year masked gods will appear in the pueblo villages of our Southwest, and up in New York State, Iroquois Indians will appear in their terrifying wooden false faces to drive away disease. Face painting is simpler than the mask but often serves the same purpose, as when the Plains Indian, wishing to appear as a supernatural bear, makes black marks across his eyes and at the corners of his mouth. In fact all ceremonial face painting is designed with the same objective in mind as is symbolized in the mask, for when the appropriate symbols are made upon the face of the native he is to all intents and purposes the god or demon he impersonates. Impersonation is so basic in human behavior that even children spontaneously take it up. Possibly primitive face painting is older than the use of masks but both survive to this day.

Fig. 62—AN AUSTRALIAN NATIVE DRESSED FOR A CEREMONY

In this case the mask is built up on his own face, with plastic materials and down. However, it serves the purpose of a mask, the wearer impersonating one of the totemic gods. Arunta tribe.

Fig. 63—This animal face has a movable lower jaw which the wearer manipulates by a string. It is a grotesque, but on the whole, a pleasing face, suggesting laughter. Vancouver Island, British Columbia.

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THE ROAD TO MAN

By

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Brooklyn College

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GUIDE LEAFLET SERIES
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THE ROAD TO MAN

By ERICH M. SCHLAIKJER *Brooklyn College*

THAT man is the product of a continuous development from the earliest form of life that appeared eons of time ago, is by no means a new idea. This concept, with modification, was partly foreshadowed in the writings of some of the earliest naturalist-philosophers, and during the past one hundred and fifty years, many scientists in the biological, geological, and related fields have amassed a wealth of scientific data portraying with great accuracy the gradual transformation that has taken place from the earliest fish-like vertebrates to fishes, amphibians, reptiles, and to mammals leading eventually to man. Preëminent among the outstanding later contributors to the subject of man's place in relation to the lower vertebrates have been such men as Darwin, Haeckel and Huxley, and most notable at present is the work of Professor William King Gregory* whose many contributions, dealing with the stages of the evolution of man from the earliest fishes, are well known.

Likewise, the pictorial representation of stages in man's ancestry is not new. Several have done this, but they have not used as many forms and have employed, wholly or in part, living animals. The present attempt, however, is to portray, for the first time, a continuous series of restorations of thirty fossil forms in or near our ancestry from the earliest vertebrates of four hundred and fifty million years ago. These have been selected from the thousands of known fossil vertebrates because they best display the structural features necessary for giving rise to progressively higher forms, and have not been side-tracked by overspecialization from the road to man. It should be remembered that this road was a crowded one and that these chosen few represent only stages whose structural features characterize groups along the way. Evolution is not a matter of steps nor is it a condition of change from one individual to another. It is a slow transformation from lower to higher types—new groups gradually emerging from old ones.

When vertebrates appeared, more than three-fourths of the earth's history had passed. Since then, however, much has happened to the ever-changing features of the earth's crust, and there have been many marked environmental changes. The first vertebrates were fresh water forms of a time when there were no land plants, and the continents were transgressed by extensive seas. By the close of Devonian times there had been marked restriction of the seas, forests of spore-bearing plants covered the landscape, and the first amphibians appeared. They found the warm, humid climate of the Carboniferous Period, with its extensive, heavily forested swamp-lands most acceptable and they developed abundantly. One group took to the land and from them evolved the reptiles which were already flourishing at the end of the Paleozoic Era. This great Era was brought to a close by the Appalachian Revolution. Mountain systems were built up where once there had been seas and marsh lands; moisture-laden winds were cut off from regions that were once humid, turning them into deserts; and, this universal diastrophism had much to do with bringing about rather extensive glaciation. These changes lasted on into the early Mesozoic and had profound effects on the animals and plants of the times. Amphibians were restricted and many diverse reptilian forms had developed. The mammal-like forms eventually gave rise to the mammals, which soon were to become varied but were for the next 140 million years to occupy an inconspicuous place in a world of reptiles. Among the plants, cycads and conifers (pines, etc.) were now dominant.

By late Mesozoic times the seas were once more widely transgressing the continents. Extensive sections were turned into swamp-lands, and flowering plants were widespread and abundant. Another great revolution brought this Era to a close, and the effects on life were as striking as before. This really marked the dawn of modern life. Mammals were established and such plants as grasses, cereals, and fruits began to flourish.

As early as the Miocene Period, uplifting began again and culminated in the Ice Age. Coincident with these severe conditions was the change from the man-like apes into man and it was during the critical times of the Pleistocene, when nearly one-sixth of the land surface was periodically covered with ice, that man fought his way to a higher evolutionary plane.

These are the main environmental changes, which during the last 450 million years, have marked the way of vertebrate evolution along the road to man.

* See especially, "The Origin and Evolution of Human Dentition," Williams and Wilkins, 1922, and "The New Anthropogeny: Twenty-five Stages of Vertebrate Evolution from Silurian Chordate to Man," Scien. 77: 29-40, 1933.

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[illegible] … ANCESTRAL [illegible] … are known … shows a network of sensory canals, gill … pouches … seven semicircular canals. In all these features these fishes point the way to … first jawed relatives. The ANCESTRAL APHETOHYOIDS (3) formed a shark-like group unique in having … that corresponds to our eustacean tube. They are for the most part primitive and foreshadow the oldest known ray finned fish CHEIROLEPIS (4). This progressive type has started on the road to higher ray-finned fishes but has retained many structures especially in the dimensions and positions of the skull bones, of our early lobe finned Devonian ancestors.

The most primitive of these was OSTEOLEPIS (5). Their lobe-like fins, fringed with dermal rays, were differentiated internally into elements that were to become the bones of our limbs. Nostrils opened into the roof of the mouth showing the probable presence of lungs.

One of the most advanced of these fresh-water, medium-sized, carnivorous forms was EUSTHENOPTERON (6) of Canada. He could paddle his way out of the water and was far on the way to becoming an amphibian. The early fish-like amphibians spent most of their life in water yet had many characters necessary for success on land. Such were the ICHTHYOSTEGALIANS (7) from East Greenland—the first tetrapods, or four-legged vertebrates. Bones between the skull and shoulder covering the gills were lost and the first neck appeared. In the specialized yet primitive EOGYRINUS (8) the shoulder-girdle is still attached to the skull. Having to hear through air, the first major step in the development of our refined hearing apparatus was taken when the upper bony support of the old hyoid gill was transformed into a little bar (stapes) connecting the inner ear with an external drum. One group of amphibians, represented by DIPLOVERTEBRON (9) from the Carboniferous of Bohemia, took to the land more and more, became quite lizard-like, and had well developed limbs. Eventually they changed into reptiles—the next higher group of vertebrates. SEYMOURIA (10), the amphibian-reptile from Texas, shows this transformation—a change that meant, among other things a better developed brain, costal (rib) breathing and that eggs could be laid on land. This change was the product of trying conditions at the close of the Paleozoic. ROMERIA (11), also from Texas, was a more advanced member of this stock. Known only by the skull this form seems to stand at the cross roads that lead in one direction to many of the highly specialized and later reptiles, and in the other to CAPTORHINUS (12) and the mammal-like reptiles. This small form had rather slender limbs. The skull had most of the primitive elements but the teeth were rather specialized possibly for eating molluscs along the shores of Permian seas. More advanced, however, was MYCTEROSAURUS (13), which belonged to an order of the more common Texas Permian reptiles.

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Characterized by its large eyes and fairly deep, long face, it foreshadows many of the features of the mammal-like cynodont (dog-toothed) reptiles of South Africa. CYNOGNATHUS (14), the dog-jawed reptile, has progressed towards the mammals in such features as reduction of the posterior jaw elements, differentiation of the teeth, limbs under the body, and a shoulder-girdle that closely resembles and has the same elements as the egg-laying mammals of today. TRINAXODON (15) was even a more mammal-like cynodont

NATURAL HISTORY MAGAZINE, By ERICH M. SCHLAIKJER Drawn by GEORGE F. MASON OCTOBER 1938

The transition from reptile to mammal was a gradual one and the rare ICTIDOSAURIANS (16) from South Africa bridge the gap perfectly. Though still on the reptile side known parts of the skeleton are unbelievably mammalian. The dentary bone of the jaw has nearly formed the skull. When this happened … which reduced bones of the old jaw skull joint were taken over into the middle ear. Mammals were born and our hearing apparatus established. AMPHITHERIUM (17) of the English Middle Jurassic represents the Pantotheria (all-mammal), an order of mammals ancestral to all the later higher forms. Only jaws are known but they show no specializations and much can be inferred concerning the rest of the animal. ADVANCED PANTOTHERES (18) known by teeth and jaws of *Melanodon* and others of these pre-placentals, by the close of the Jurassic foretell the earliest known placentals, or insectivores, of the later Cretaceous. A half dozen skulls from Mongolia represent the first of these DELTATHERIDIUM (19), the most archaic, whose restoration is based on two skulls, is much like later fossil and primitive living forms. It typifies the ancestor of a tree-living line that gave rise to our first immediate ancestor. We know this INSECTIVORE-PRIMATE (20) stage in our evolution through fossil teeth and jaws, and especially by their very primitive living descendants, the tree shrews of the Far East. ANCESTRAL LEMUROIDS (21) were the first true primates. Their remains are found in early Paleocene rocks in the Rocky Mountain States. Though specialized, they reveal many of the structures and habits of the lemur ancestry, portraying in general our earliest primate tree-living ancestors. By Eocene times true lemurs were well established in the Old and New Worlds. PELYCODUS (22) was a small primitive form with teeth that recall an early lemuroid ancestry. More progressive was the American *Notharctus*. PARAPITHECUS (23) of the Oligocene of Egypt had advanced more in the direction of the ancestral anthropoids, possessing the features of the teeth necessary for giving rise to monkeys and apes. Egypt was also the home of the earliest known ape. From deposits there, a single lower jaw named PROPLIOPITHECUS (24) has been described. Its form and tooth characters show that this progenitor of ours was decidedly like living apes though far more primitive, as are all ancestral forms. More ape-like, yet more primitive than any of the chimpanzee-gorilla group was DRYOPITHECUS (25). Fragmentary remains of this stock have been recovered from parts of Western Europe and India. Unquestionably these display, especially in the form of the teeth and in the number and arrangement of the tooth-cusps, an ancestral stage common to the orang, gorilla, chimpanzee, and to man. AUSTRALOPITHECUS (26) of the Pleistocene of South Africa combined in a unique way ape-like and man-like characters. It was a structural connecting link between the two families. The oldest and most primitive of fossil man is the Peking SINANTHROPUS (27). Several skulls, jaws, teeth, skeletal fragments, stone implements, and charcoal unearthed in an early Ice-Age cave deposit tell the story of this cannibalistic forefather of all modern races. Towards the close of this Period *Homo sapiens*, the species to which we belong, had appeared. An early generalized member is the WADJAK MAN (28) of Java. In his many primitive skull characters, this lantern-jawed individual closely resembles the Australian and could be the ancestor of all later forms including the advanced CRO-MAGNON MAN (29). This cave-dweller possessed a few primitive features, but had a superior brain volume, averaged six feet tall and had a high degree of artistic ability as is shown by paintings, carvings, etc. This European was contemporaneous with the extinct mammoth of pre-Recent glacial times, and may have been ancestral to some of the white race of HOMO SAPIENS (30) of today.

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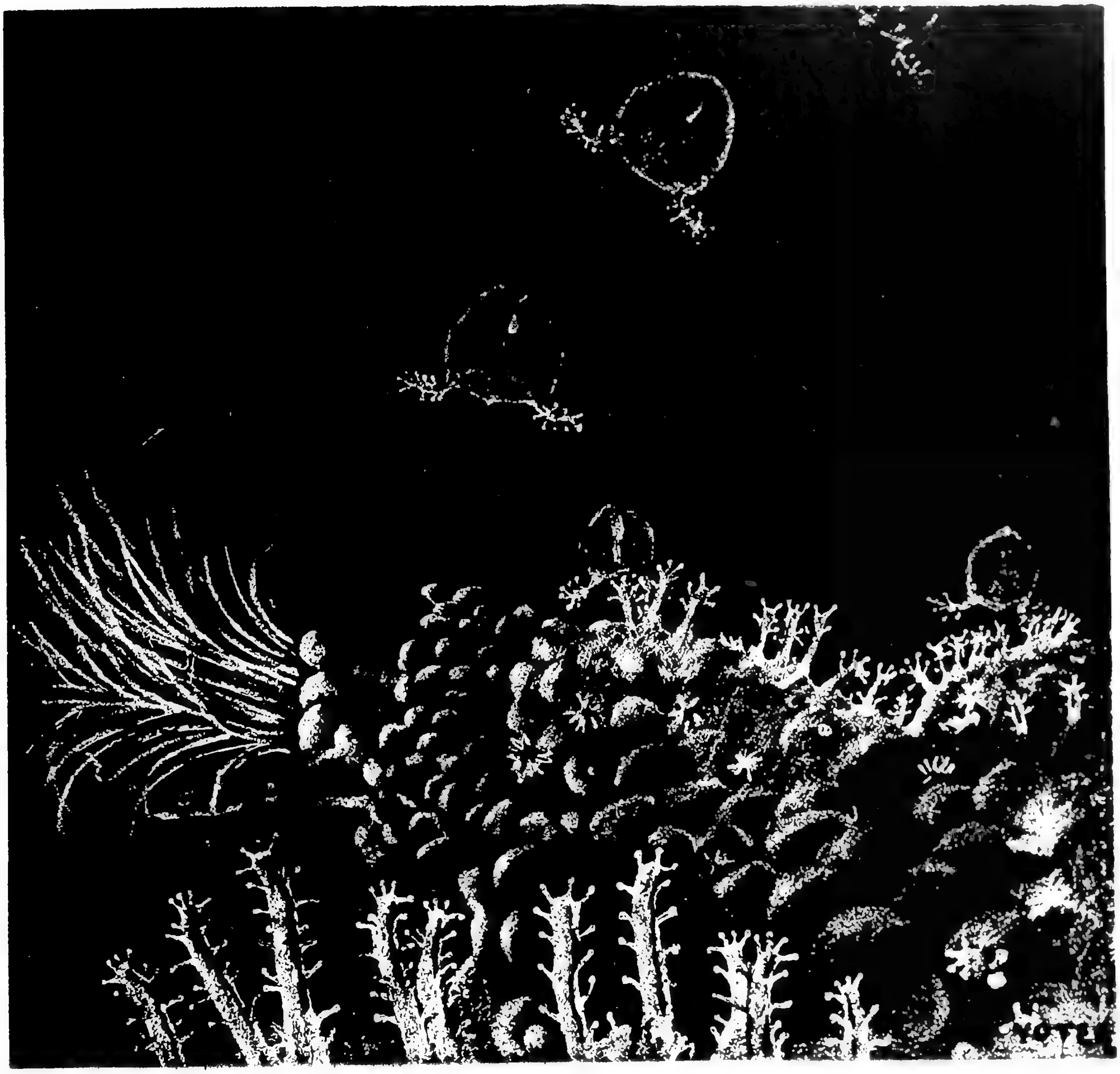
FRAGILE CREATURES OF THE DEEP

BY ROY W. MINER



THE AMERICAN MUSEUM OF NATURAL HISTORY

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FRAGILE CREATURES OF THE DEEP

By

ROY WALDO MINER

Curator of Living Invertebrates, American Museum of Natural History

GUIDE LEAFLET SERIES

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No. 98

Figure 1. *Greatly enlarged model of the original scallop-shell described in the text, now on exhibition in the Darwin Hall of the American Museum. The inset in the upper left-hand corner shows the natural size of the shell.*

A colony of Carnation Worms (Hydroides dianthus) *has encrusted the shell with their dwellings,—a series of coiling limestone tubes from which the heads of the worms have extended their flower-like circlets of breathing-plumes varying in color from bright orange and white to pink, blue and gray. Covering these tubes are colonies of moss-animals, hydroids and protozoa as shown in greater detail in Figure 2*

FRAGILE CREATURES OF THE DEEP—*The story of the hydroids and their kind, whose schemes for coöperative social organization, specialized labor, and collective security set a Utopian example man would find hard to equal*

By Roy Waldo Miner
Curator of Living Invertebrates, American Museum of Natural History

A DEAD scallop-shell lodged between two stones in the swift current attracted my attention. It was covered over with irregular growths of a reddish color, with dots of blue and orange scattered here and there. I reached down to dislodge it from its anchorage in the tidal stream, placed it in a glass jar of sea-water partly filled with other specimens, and brought it back with me to the laboratory.

The scallop-shell was then transferred to a glass dish beneath a stream of gently running sea-water, and some time later I examined it under the low power of a binocular microscope. Immediately I was held spellbound, transported into a world of delicate beauty. My dead shell had sprung to life!

A colony of serpulid seaworms *(Hydroides dianthus)* had built their tiny limestone tubes in a coiled cluster over the fluted scallop-shell, each with a little round opening at the end about an eighth of an inch in diameter but magnified by my instrument to a sizable cavern *(Figure 1, opposite)*. Feathery tufts of orange, purple, and rose slid into view from each opening and expanded into petal-like crowns of gorgeous plumes, flaunting bands of crimson, blue and gold, set off by translucent collars of green and yellow.

The terminal portions of the tubes projected from beneath a brick-red calcareous crust, which completely covered the intertwined coils of the stony dwellings. This crust resolved itself into thousands of tiny vases with perforated walls. From the mouth of each vase a graceful, golden lily-like head protruded *(Figure 2)*. I recognized a species of moss-animal or sea-mat *(Schizoporella unicornis)*, so-called because of its spreading habit. Within my field of view thousands of these little creatures reared their delicate heads in regular ranks and as a shadow passed above them instantaneously disappeared within their shells. Soon they slowly emerged, unfolding their circlets covered with moving hairs to ensnare still tinier creatures and engulf them within their gaping central mouths.

This microcosmic world was so complex, and each detail so interesting, that only after an interval did I perceive hundreds of other fairy creatures standing erect between the shells of the moss-animals. Some were club-shaped, being expanded at the top, and all were translucent, disclosing within their elongate bodies an interior lining of rose-color. Their sides were adorned with stiff, outstanding tentacles, each terminating in a ball-like knob. As I watched, a tiny protozoan came blundering through the forest of fingers. It touched one of the knobs and after a twitch or two, suddenly ceased to move. It had been stung to death by the battery of sting-cells with which each knob was equipped and soon was drawn into the mouth which now expanded to receive it.

These creatures, of such fragile beauty, apparently so innocent, are in reality voracious hydroids of the species *Zanclea gemmosa,* extending their death-dealing weapons in all directions to slay small swimming animals that may come in contact with them. As I gazed through their crowded ranks, I noticed that many had a small ball-like projection on one side. In others, this had grown to a considerable size and was becoming indented to resemble a saucer. In one individual directly beneath my eye, the saucer had expanded to a transparent bell with a tiny clapper hanging down within it. Tentacles with knobbed branches extended in opposite directions from the margin of the bell. As I watched, the stem by which it was attached narrowed to a tenuous thread. Suddenly, struggling with vigorous spasmodic contractions and expansions of its transparent umbrella, it gave a quick pull, separated from the parent stem, and swam off to lead an independent life as a tiny medusa or jelly-fish *(Figure 3)*.

The hydroid polyps are among the simplest forms of animal life, and represent the stock from which

Fig. 2

A populous community of hydroids, moss-animals and protozoa has covered the worm-tubes on our scallop-shell.

The hydroids (Zanclea gemmosa, *Inset A*), *project between the crowded moss-animal shells* (Schizoporella unicornis, *Inset C*). *Forked lappets of the swallow-tail Protozoan* (Folliculina hirundo, *Inset B*) *show between*

all higher groups sprang. They are one grade above the Protozoa, the bodies of which are composed of but a single cell or particle of protoplasm, the basic living substance.

The hydroids also at the beginning of their life-history, start out from a single-celled egg, comparable to a protozoan, but they then go through a process of cell-division which results, first, in a mulberry-like cluster of cells; second, a stage in which these form a single layer of cells arranged like a hollow ball; and, third, the final essential phase, in which some of the cells push inward and line the cavity with a second but internal layer. The forming of this layer is shown in Figure 4, a-c. The embryo then elongates to form a tube *(4d)*, which attaches itself *(4e)*. A circular mouth appears at one end, around which a series of hollow arms or tentacles develops, and thus the adult polyp is produced*(4f, g)*. The cells of the layer lining the cavity of the tube remain large and secrete digestive ferments, while the outer layer becomes composed of smaller cells which are compact for protection, and sensitive so as to react to impulses from the environment.

Some of the cells, located in the tentacles, are unusually sensitive, and become quite complex, forming thread-cells. These are bulb-like and contain a turgid fluid, within which a delicate hollow

Figure 4. *Free-swimming embryo of hydroid. Formation of inner layer, cells produced from outer layer pushing inward to fill cavity* (a and b), *and splitting apart to produce a two layered embryo* (c),*which elongates to form a*

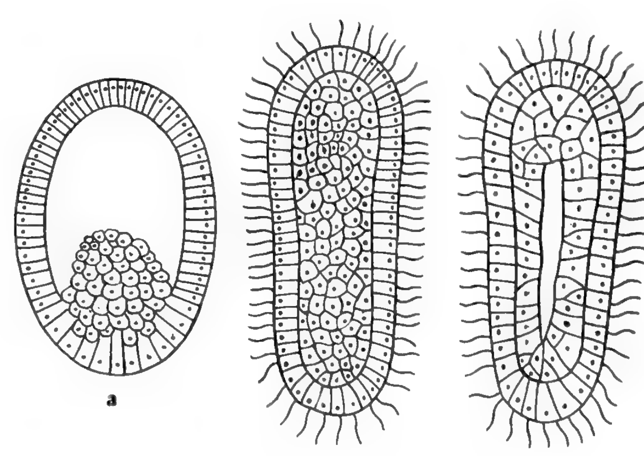
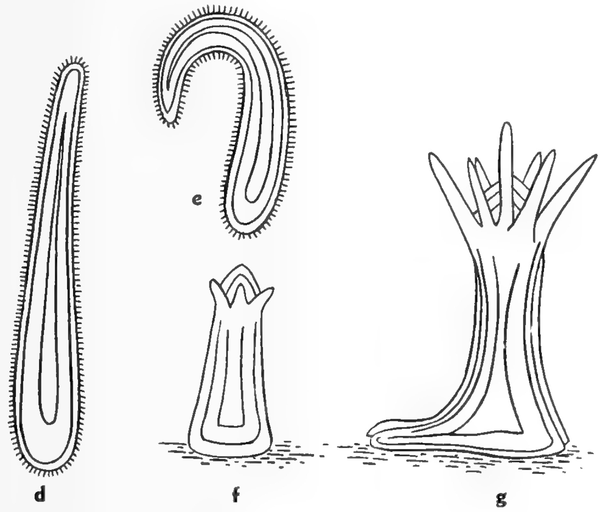


Fig. 3

Above, at left: the head of the sand-mason worm projects from its home of cemented sand-grains. To the right small medusae with bubble-like umbrellas are seen newly budded from their stationary hydroid-parents to form a free-swimming generation. They, in turn, hatch larvae to produce stationary hydroids.

free-swimming planula (d). *This soon settles down* (e), *its blunt end resting on sea-bottom and flattening, while mouth and tentacles appear at free end* (f, g)



thread is coiled like a lasso. Sharp chitinous pieces are contained within the blind terminal cavity of this thread. Projecting outside the cell are one or more sensitive hairs, the cnidocils, or triggers. When some creature comes in contact with them, the thread-cell contracts, squeezing the turgid fluid, which shoots out the coiled thread, turning it inside out with considerable force, so that the sharp chitinous pieces come together to form a barbed point. This penetrates the intruder, injecting at the same time a paralyzing poison. The thread-cells, or, as they are also called, lasso-cells, are very minute, but multitudes of them are shot out to take effect at the same time. The prey is therefore killed or stupefied and is drawn by the tentacles into the mouth so that the creature is soon engulfed within the cavity of the hydroid and digested.

Fundamentally the hydroid structure forms the basis of the evolution of the higher phyla. In fact, all higher animals culminating in man go through what essentially may be termed a "hydroid stage" in their development. That is, from a single-celled egg, they pass through cell-divisions which are more or less comparable with those of the hydroid; namely, a *morula* or "mulberry stage"; a *blastula* or single-layered "hollow-ball stage," and a *gastrula* or double-layered "hydroid stage." Likewise, in all higher animal forms, from the outer protective and

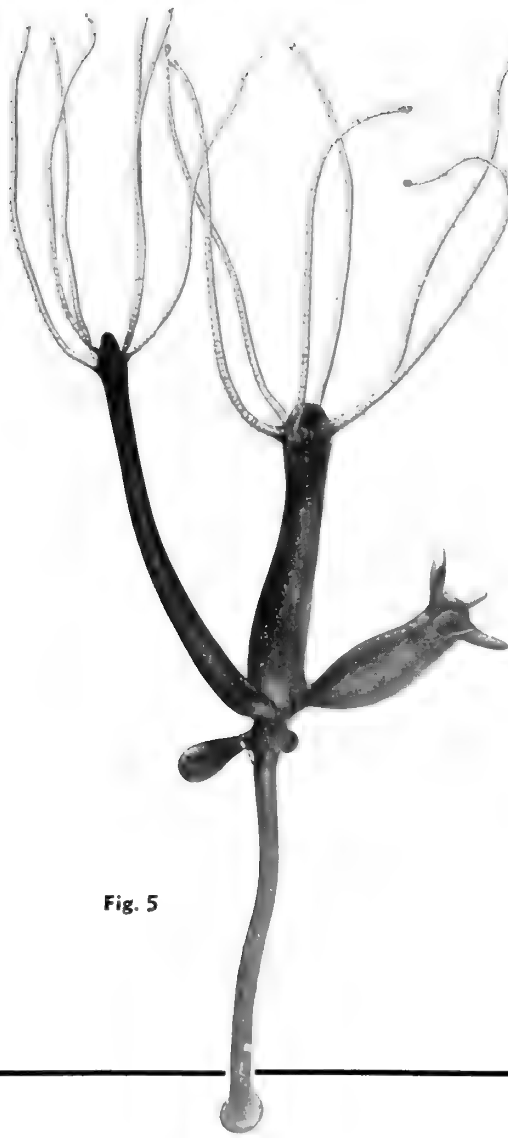


Fig. 5

sensitive layer of cells of this latter stage (the ectoderm) are derived the skin and all protective structures, as well as the brain and various complications of the nervous system. From the inner layer, or endoderm, are derived the digestive system and all contributing glands; and also, through the intermedium of cells or out-buddings of tissues from this inner layer, are formed the body-cavity linings, blood-vessels, connective tissues, inner skeletal structures, reproductive organs and certain parts of the excretory systems of higher animals. So, back in the early history of the earth, the lowly hydroid polyp and its relatives, laid the foundation of higher animal evolution. Fortunately, members of the group have been preserved to us relatively unchanged, as well as groups representing various stages in realizing the possibilities of the hydroids' pioneer work, and these have formed the great animal phyla now existing on the earth.

The hydroids, and their relatives, the jelly-fishes, sea-anemones, corals, gorgonians, sea-pens and the like are comprised within the phylum Coelentera, which includes the animals in which the entire interior of the body acts as a digestive cavity. The Hydromedusae comprise that part of the phylum which centers around the hydroids and many of the jelly-fishes as well as those marvelous floating colonial creatures, the Portuguese Man-of-War, Porpita, Velella, and their relatives. As these form a remarkable series of unusual structures and adaptations, it is planned in this article to describe some of the outstanding species and their habits.

The simplest member of the hydroid group is the fresh-water hydra *(e.g., Hydra fusca),* illustrated in

(Above) *The Fresh Water Hydra is one of the simplest of all the many-celled animals. The inch-long body is a double-layered tube. A terminal mouth is surrounded by stinging tentacles which slay small aquatic creatures to be digested within the tube. The young are budded off and separate from the parent to lead an independent life.* (Model in Darwin Hall)

(Right) *Glass model of a typical marine hydroid medusa* (Syndictyon angulatum) *related to those in Figure 3. Note the transparent umbrella, within which hangs the tubular stomach with terminal mouth. Each of the four tentacles has an eye-spot at its base.*

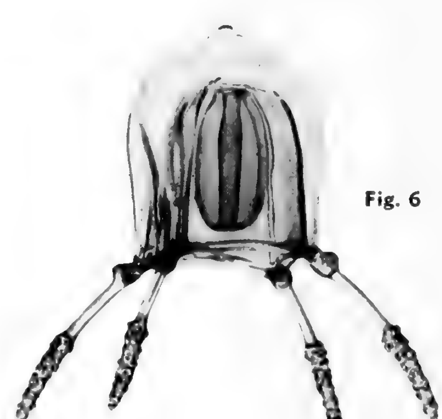


Fig. 6

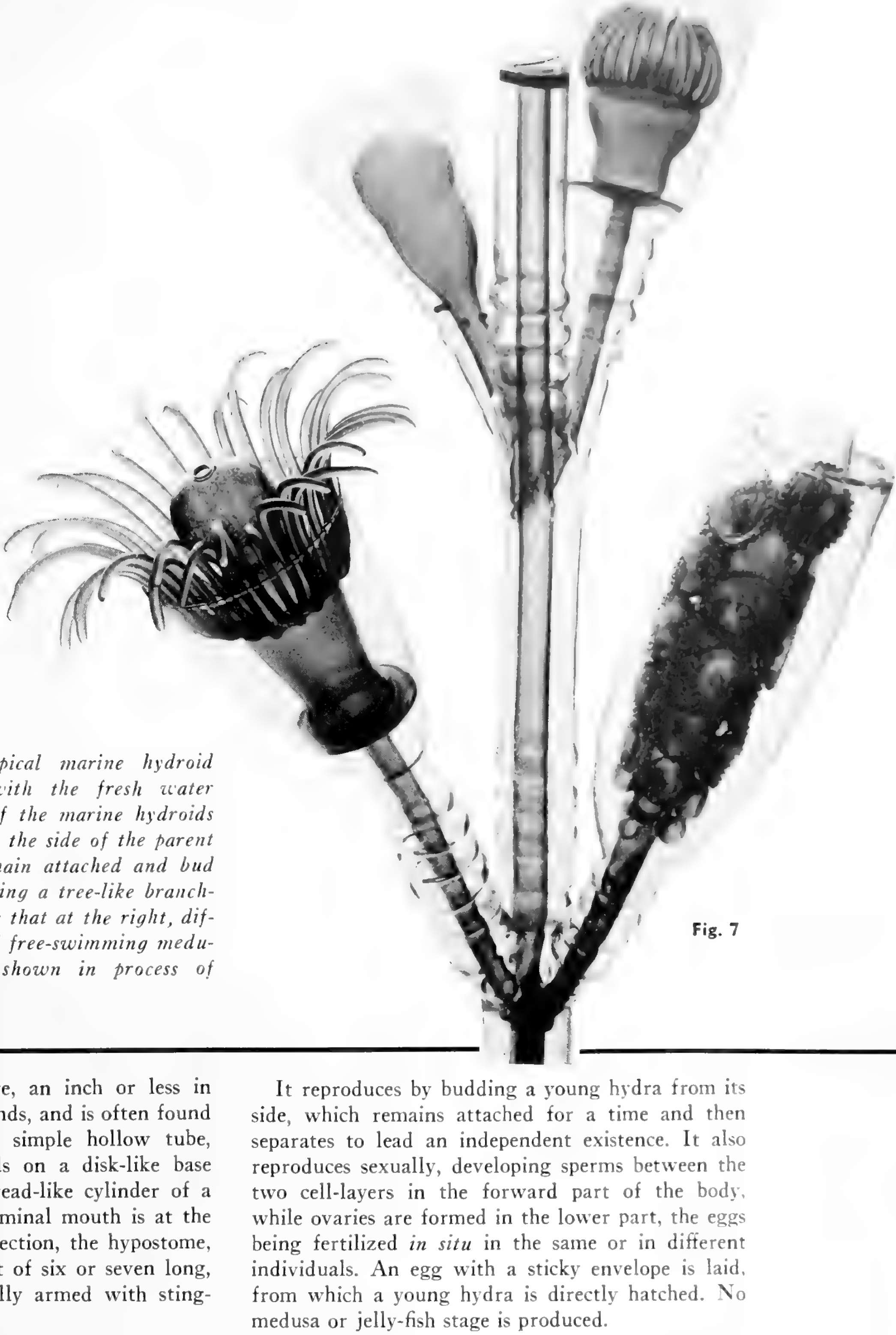


Fig. 7

Figure 7. *Model of a typical marine hydroid* (Obelia) *for comparison with the fresh water Hydra* (Figure 5). *Many of the marine hydroids bud off new individuals from the side of the parent but, unlike* Hydra, *they remain attached and bud off others in turn, thus forming a tree-like branching colony. Certain buds, like that at the right, differ from the rest, and bud off free-swimming medusae, several of which are shown in process of development*

Figure 5. This little creature, an inch or less in length, lives in fresh-water ponds, and is often found in balanced aquaria. It is a simple hollow tube, brown in color, which stands on a disk-like base and stretches out its tiny thread-like cylinder of a body into the water. The terminal mouth is at the summit of a cone-shaped projection, the hypostome, and is surrounded by a circlet of six or seven long, filamentary tentacles plentifully armed with sting-cells.

It captures fish fry, worms, and small crustacea for food, moving about from place to place, either slowly creeping upon its disk-like attachment or, more rapidly, by a series of "hand-springs." That is, it bends its body over in a loop, takes hold of the bottom with its tentacles, and deliberately stands on its head to turn a somersault. Then the process is repeated.

It reproduces by budding a young hydra from its side, which remains attached for a time and then separates to lead an independent existence. It also reproduces sexually, developing sperms between the two cell-layers in the forward part of the body, while ovaries are formed in the lower part, the eggs being fertilized *in situ* in the same or in different individuals. An egg with a sticky envelope is laid, from which a young hydra is directly hatched. No medusa or jelly-fish stage is produced.

Our marine hydroids of the dead scallop shell *(Zanclea gemmosa)* attain the next stage in advancement. The hydroid polyps are budded off from a horizontal branching stem, or hydrorhiza, which weaves its way around and among the moss-animal shells. They do not separate from this stem, thus forming a connected colony, which continually spreads by budding off new individuals asexually. As

already described, these polyps, in turn, bud off free-swimming medusae, as the hydroid jelly-fish stage is called. They are like transparent umbrellas *(see Figures 3 and 6)*, with a little horizontal shelf or velum surrounding the bell-opening, while the mouth is at the end of the hollow tubular stomach (manubrium) hanging down like a clapper inside the bell.

There are four canals radiating from the stomach in the substance of the bell to connect with a marginal canal around the rim. The young medusa has two tentacles armed with sting-cells, while there are usually four in the adult. In the latter stage, the walls of the manubrium are swollen by the developing gonads or sex-cells. The fertilized eggs give rise to free-swimming larvae, which settle down on the bottom and grow to form new hydroid colonies.

This method of reproduction is known as alternation of generations, and often occurs in this phylum (e.g., *Obelia, Figure 7*). Thus, a hydroid grows from the larva and buds off other individuals asexually, which remain connected with it. This asexual hydroid generation gives rise by budding to a free-swimming medusa generation which, in turn, produces free-swimming larvae by sexual fertilization. These larvae give rise to a new asexual hydroid generation, thus completing the cycle.

In *Zanclea* the hydroids in the community are all of the same kind. However, if, when collecting in shallow water, one watches the smaller hermit crabs, *Eupagurus longicarpus*, the shells of certain individuals will be seen to have reddish velvety covering *(see Figure 8)*. If such a crab is placed, shell and all, under the dissecting microscope in a dish of sea-water, this will blossom forth into a remarkable colony of hydroid individuals, represented in Figure 9. This species *(Hydractinia echinata)* penetrates the shell-substance to form a network of tubes connecting the members of the colony with each other. The community includes three different kinds of polyp, each specialized for a definite function. The first are the feeding-polyps, with club-shaped bodies and terminal mouths surrounded by a single ring of tentacles. These capture the prey, swallow it, and proceed to digest it for the benefit of the entire community, passing it along through the system of underground tubes.

This is just as well, for the other two kinds of polyps possess no mouths or tentacles and are, therefore, dependent on the feeding polyps. The second series is specialized as reproductive polyps, bearing around their bodies grape-like clusters of medusa-buds. These never develop into free-swimming medusae like those of *Zanclea*, but remain attached, in partially developed condition. Ova and sperm are produced, however, and the former are fertilized *in situ*, giving rise to larvae from which new polyps are directly developed.

The third kind of polyp is the fighting or defensive polyp. It occurs abundantly along the edge of the snail-shell and around the margins of the colony. The individuals are long and slender. Their summits are equipped with spherical batteries of powerful sting-cells. These three kinds of polyps act together for the common good and also form a

Figure 8. *Two specimens of hermit crab* (Eupagurus longicarpus) *with a smaller individual "stealing a ride," photographed from life. Note the velvety surface on the shells of the larger crabs caused by colonies of the marine hydroid,* Hydractinia echinata, *which completely cover it. This hydroid colony comprises hundreds of individuals connected by a network of tubules penetrating the substance of the shell. Figure 9 shows a portion of this colony greatly magnified*

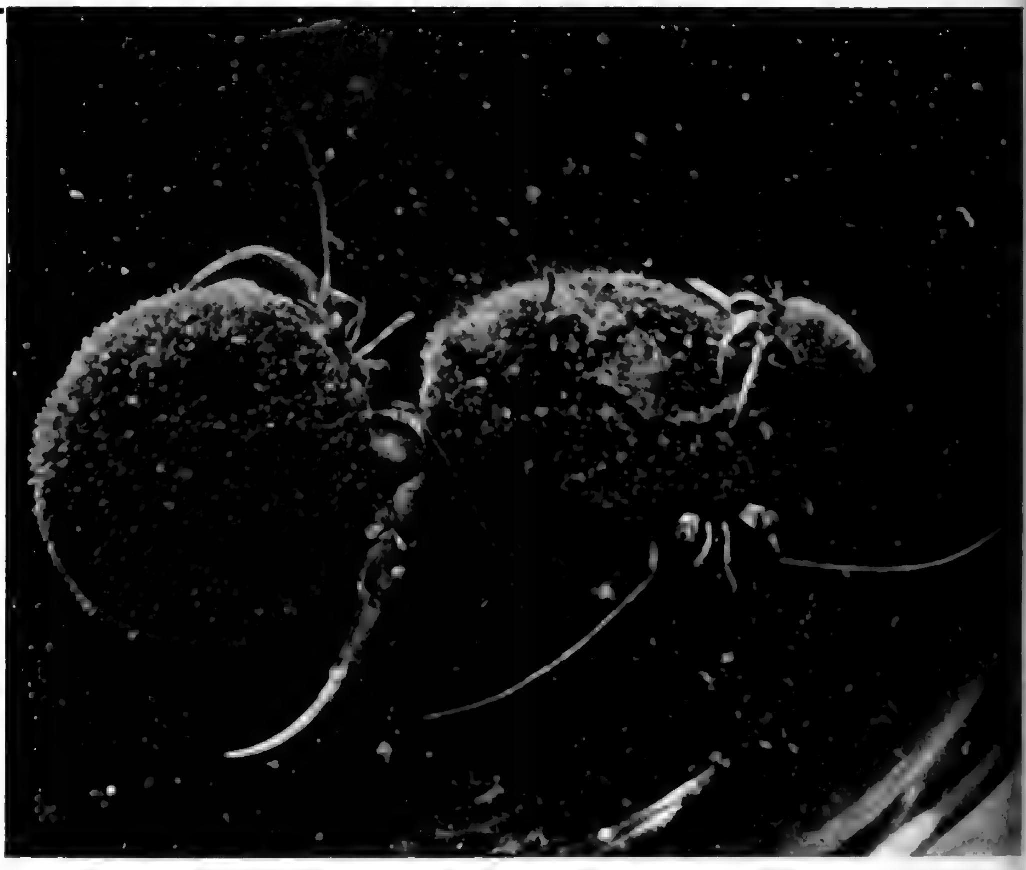


Fig. 8

partnership of mutual benefit with the hermit crab which wears them on its shell. The crab transports them from place to place, thus bringing them to new feeding grounds, where they profit by the minute creatures swimming in the water. The crab also tears to pieces larger prey, the fragments of which float up to form part of the food of the hydractinian colony. On the other hand, the fighting polyps not only act as defenders for their own community but also for the crab itself, because they aid in slaying the creatures on which it feeds.

Thus, two principles are introduced into the hydroid world. The first of these, polymorphism, involves the production within the same colony of different types of individuals specialized for different purposes but working for the common good of the colony on a coöperative basis. This is so successful among the lower organisms that we shall find in the floating colonies of the siphonophores it has been elaborated to a remarkable degree. If mankind were as successful in his coöperative schemes, we should have no difficulty in establishing an ideal Utopian form of government. Perhaps the lowly forms of life are more perfectly constituted for altruism.

The other principle referred to is that of copartnership with other unrelated species as, for example, the *Hydractinia* and hermit crab from such diverse groups as the Coelentera and Crustacea respectively. This phenomenon is usually referred to as commensalism, when the partnership involves sharing the same food.

Fig. 10

Figure 10. *A solitary marine hydroid* (Tubularia harrimani). *It does not bud to form colonies. Instead medusa-buds are produced which remain attached in bunches. They give rise sexually to fertilized eggs from which hatch free-swimming larvae to develop into new hydroids* (From Glass Model)

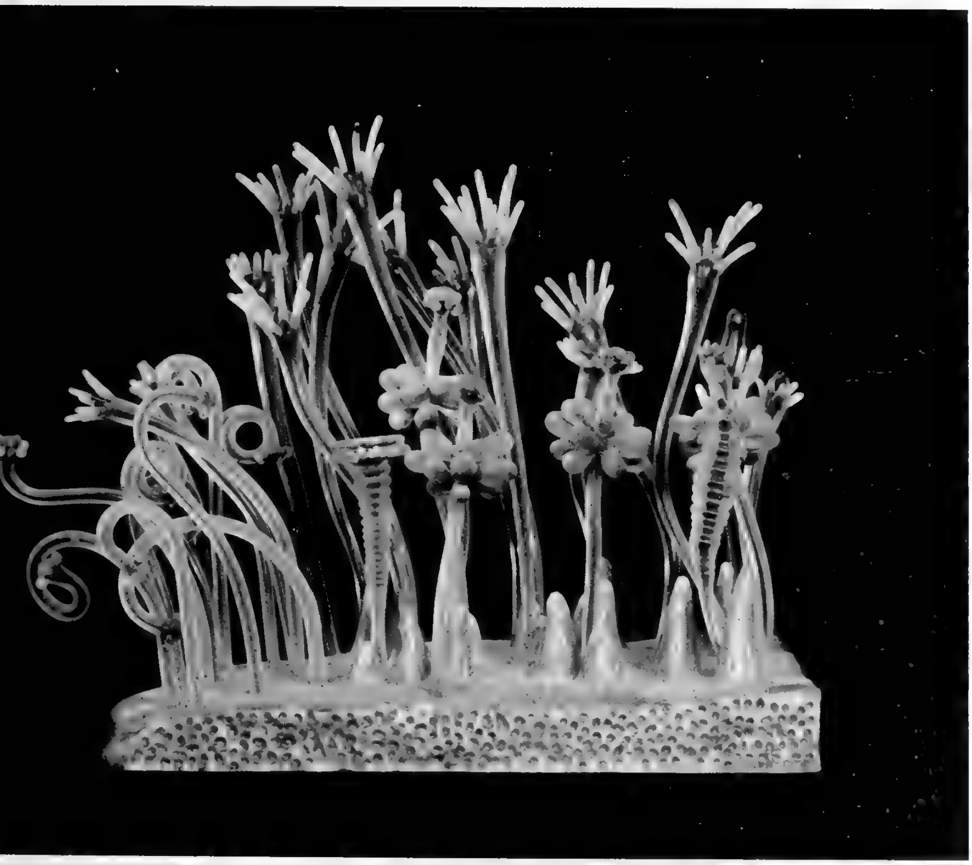


Figure 9. *Model showing section of hermit-crab shell* (see Figure 8) *greatly enlarged to show the specialized individuals making up the colony of* Hydractinia *growing on the shell. Three varieties of hydroid polyp are shown-- feeding polyps, fighting polyps, and reproductive polyps. (See text for details)*

Fig. 9

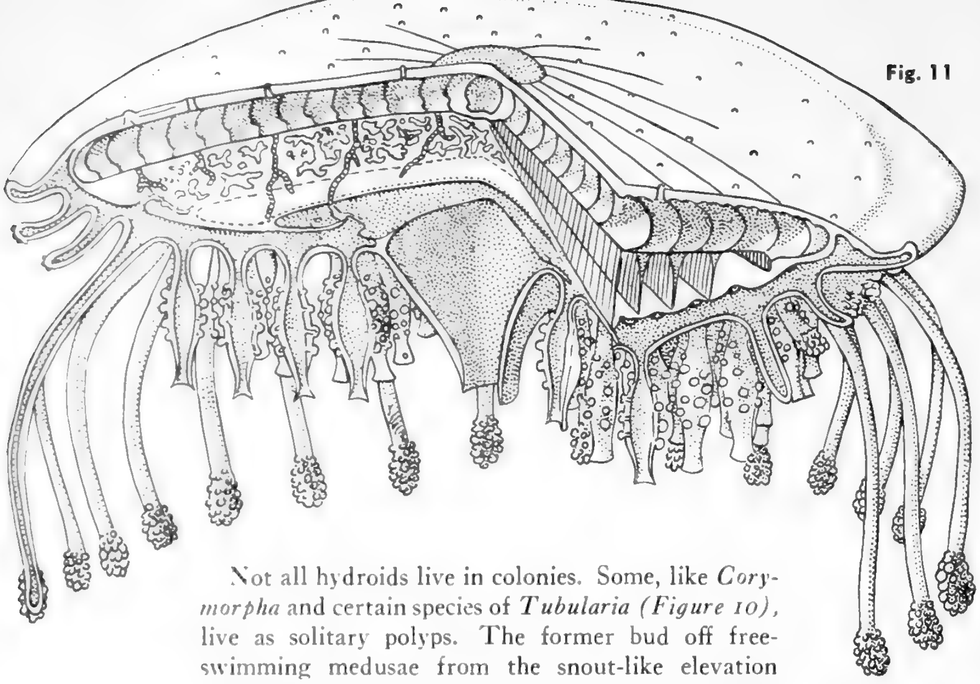


Fig. 11

Figure 11. *Diagram showing structure of the siphonophore,* Porpita (modified from Delage and Herouard). *This is a floating colony kept at the sea-surface by the complicated air-chambers of the central parent individual, the large mouth and stomach of which may be seen hanging down in the center. This is surrounded by several circlets of tube-shaped feeding individuals having mouths. Around the border of the colony are circlets of mouthless fighting polyps armed with sting-cells. The air-chambers are filled with a gas secreted by the parent polyp*

Not all hydroids live in colonies. Some, like *Corymorpha* and certain species of *Tubularia (Figure 10)*, live as solitary polyps. The former bud off free-swimming medusae from the snout-like elevation (manubrium) which terminates in the mouth. The latter produce medusa buds which never reach the stage of complete medusae and always remain attached. The *Corymorpha* medusae have beautifully delicate little umbrellas with a single tentacle attached. They give rise to sex-cells after becoming free-swimming. On the other hand, the *Tubularia* produce their sex-cells early and, as they are never free-swimming, they might almost be interpreted as sex-organs of the hydroid. It is thought by some that this is an initial evolutionary step toward the sex-organs of higher animals.

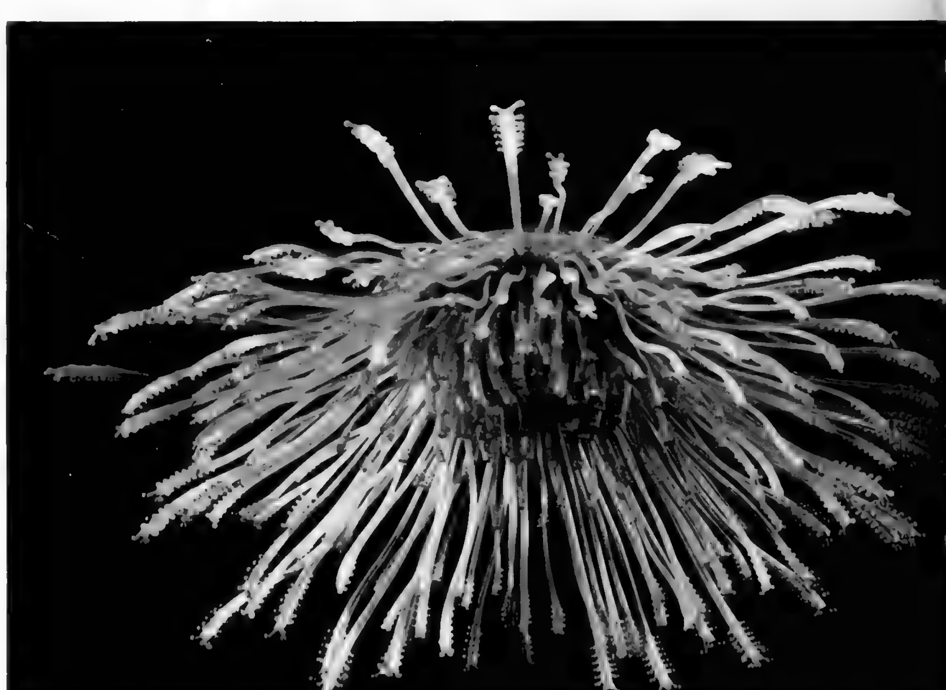
In other cases, like *Sarsia,* the medusa seems to acquire an unusual degree of importance, for after being detached from the hydroid instead of immediately producing eggs to be fertilized so as to develop a sexually formed larva, which in turn will become transformed into a hydroid, it starts budding off new medusae directly from its long pendent manubrium and these become free-swimming. So that a free-swimming medusa buds off free-swimming medusae directly. The latter, however, produce larvae sexually, and these become hydroids.

In some cases after such medusa buds reach a certain stage, they start to degenerate, losing their medusa-like organs, and finally become sporosacs, i.e., merely pear-shaped sacs from which ova and sperm are formed directly, the ultimate result paralleling the formation of similar gonads in hydroids. These are both instances in which the evenly developed alternation of generations becomes over-balanced in favor of either the hydroid or medusa generation, the alternating generation apparently becoming obliterated.

In some forms, as opposed to the condition in which the medusoid generation always remains attached to the hydroid, and is borne by it, there are certain species *(Phialidium)* in which the hydroid grows directly from the under side of the medusa-umbrella but always remains attached to it, being carried around by it from place to place. From this

Figure 12. *Model showing a colony of* Porpita *as it appears in life, slightly tilted to display the under surface. The colony is supported by a blue disk-shaped float about the size of a quarter, with the structure shown in Figure 11. The circlets of fighting polyps radiating from the margin have knob-like batteries of sting-cells at their extremities. Within may be seen the series of feeding polyps*

Fig. 12



passenger-hydroid, in turn, new medusae like its parent are budded asexually. So there are all possible stages grading from true alternation of generations in either direction, emphasizing the hydroid at the expense of the medusa, or the medusa at the expense of the hydroid.

On the medusoid side the ultimate result is found in the sub-family Trachylinae, consisting of beautiful medusae which have no hydroid stage whatsoever, giving rise to eggs which hatch out medusae like themselves without any intervening stage, with the result that alternation of generations is completely obliterated.

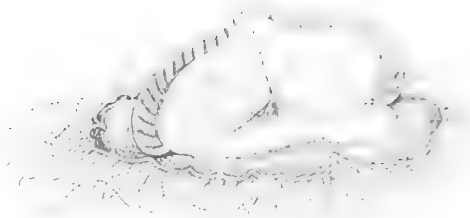
Perhaps the most remarkable specializations occur in that wonderful group of the Hydrozoa known as the Siphonophora. These are oceanic species that form floating and swimming colonies of many types of individuals specialized for diverse functions which operate for the common good. This reminds us of the feeding, fighting and reproductive individuals of the *Hydractinia* on the shell of the hermit crab, but in that case the members of the colony are anchored in the shell. The siphonophores, on the other hand, are floating colonies in which the members bud from an original floating mother-polyp that starts the colony. The best known of these floating cities are the Portuguese Man-of-War *(Physalia pelagica)* and its relatives *Velella* and *Porpita.*

Hundreds of other species belong to the group, comprising many diverse forms, involving so great a variety of complicated arrangements that it would be highly confusing to describe many of them, so our attention will be limited to a few of the most typical.

Imagine one of our medusae, as it swims about, acquiring a greatly expanded umbrella disk stiffened with concentric rows of air-chambers to aid in keeping it afloat, instead of depending on swimming by means of alternating pulsations of the disk. Suppose that circlets of polyps bud from the under side of the disk and hang down in ordered ranks arranged concentrically around the mouth and manubrium of the parent. This is the condition in the free-swimming hydroid colony known as *Porpita,* shown in Figures 11 and 12.

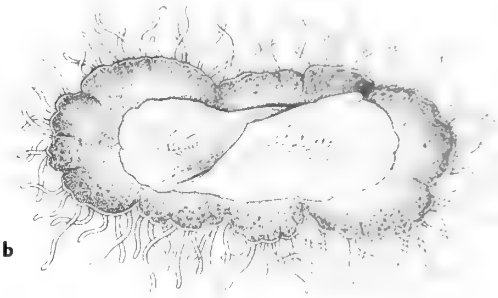
The multitudinous polyps hanging beneath it have assumed various differences in form and function. As shown in Figure 11 some look typically polyplike, having tubular or rather vase-shaped bodies with circular terminal mouths, surrounding the larger central mouth of the medusa. Around the base of each polyp are medusa buds in various stages of maturity. These are, therefore, the feeding and reproductive individuals of the colony. Surrounding them, and extending far beyond the edges of the disk, are ranks and ranks of long, slender club-

Fig. 13



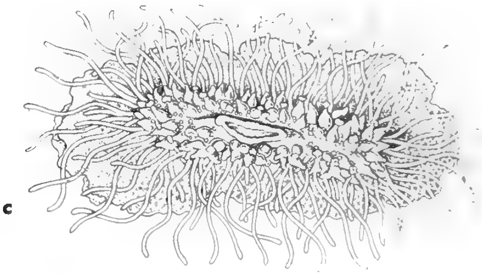
a

(Above) *Colony of* Velella *which resembles a smal. rectangular raft four or five inches in length. A peculiar sail-like structure is situated diagonally across the upper surface.* (These figures redrawn from Haeckel



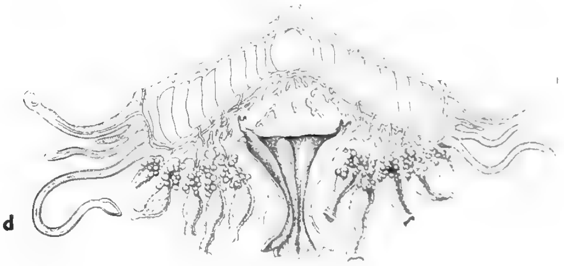
b

Upper surface of a colony showing the sail fore-shortened. The inner lighter portion is equipped with concentric air chambers. Fighting polyps project from underneath its border.



c

Under surface of the same colony showing the outer series of fighting polyps and the inner set of flask-shaped feeding polyps about the central slit-like mouth.



d

Vertical transverse section through the forward part of the float of Velella *showing the concentric air-chambers. Below are the various types of individuals described in the text. Reproductive gonads are visible around the bases of the feeding polyps*

shaped polyps, with no mouths, but fringed with tassel-like batteries of sting-cells. These are the fighting polyps, having for their sole duty the capture and slaying of prey to be turned over to the feeding polyps. It is obvious that the fighting polyps, having no mouths, must depend on their neighbors for food, which is passed to them predigested through the internal connections with the main colony. While the feeding-reproductive polyps also have sting-cells, they are not developed to the degree seen in the fighting polyps. The living *Porpita* floats and swims in great schools in the warm waters of the Gulf Stream. Each colony is a little blue disk about the size of a quarter. They are quite abundant in the open sea off the southern New England coast during the summer, especially after a southeast gale brings in spurs of the Gulf Stream.

Closely related to them is another colonial siphonophore, *Velella,* which resembles a small rectangular raft about four or five inches in length *(Figure 13).* Like *Porpita,* the raft is kept afloat by a series of concentric air-chambers, of which the inner part of the raft is constructed, while an upright crest or keel is set diagonally along the upper side of the float and apparently acts as a sail. From underneath the raft an assemblage of polyps similar to those of *Porpita* extend down into the water, including a central feeding mouth and manubrium, while around it are arranged multitudinous pendent feeding and reproductive polyps. As in *Porpita* a fringe of fighting polyps stretches out into the sea on all sides.

The most remarkable of all this strange group of siphonophores is the Portuguese Man-of-War *(Physalia pelagica),* illustrated in Figure 14. A fleet of graceful iridescent bubbles gay with intense scarlet, green and violet dances on the summer sea. But streaming far down below the surface long tentacles of blue, bordered with bead-like batteries of the most powerful sting-cells known to exist among sea-creatures, trail along like death-dealing dredges,

Fig. 14

Figure 14. *The Portuguese Man-of-War* (Physalia pelagica) *is the largest and most spectacular of the Siphonophores.*

A certain species of fish (Nomeus gronovii) *swims, immune, among its powerful stinging tentacles.* (*Life size glass model in American Museum*)

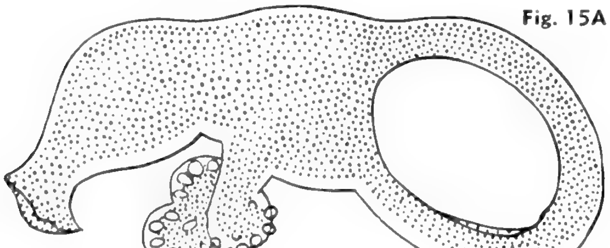


Fig. 15A

Figure 15A. *A newly hatched* Physalia *showing original polyp with open mouth and rear part of body secreting a bubble of gas. A single tentacle projects from below*

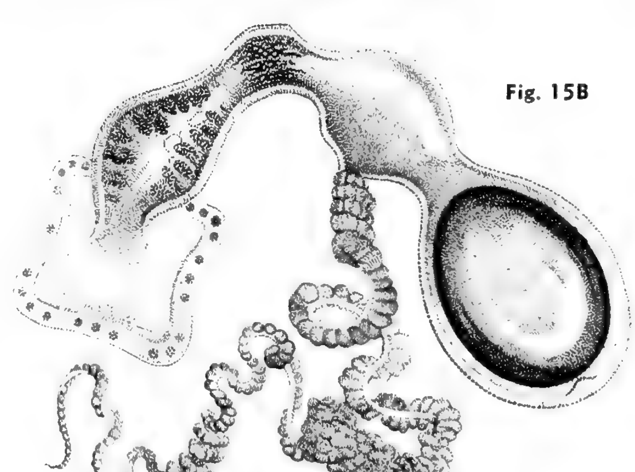


Fig. 15B

Figure 15B. *A later stage with expanded mouth, and longer and more fully developed stinging tentacle. The digestive cells show through the transparent walls of the tubular stomach*

slaying fish and all other organisms that come in contact with them. The prey adheres to the strands of this net and is drawn up by their shortening threads until it comes in contact with the hundreds of hungry mouths stretched out by the azure polyps hanging from the common float. Green finger-like polyps of great sensitivity feel over the prey and soon its juices are absorbed by the feeding polyps.

Hanging among the other individuals composing the myriad clusters of this floating colony are finely branched bunches of reproductive individuals like little pompons, salmon-pink or white in color. These are developing medusae of two sorts, male and female. The female medusae reach maturity with perfectly formed umbrellas and become detached to swim away to produce their ova. The male medusae at the base of the cluster remain attached and do not develop the umbrella structure.

It is hard to realize that these floating colonies are not single animals, so beautifully are the different sorts of polyps composing them coördinated in their functions and activities. They are, nevertheless, colonies or cities of individual polyps each of which has come into existence as a bud from a single original polyp which hatched from the egg to start the colony. In the case of the Portuguese Man-of-War, the original polyp is the float. In its earliest stages this was a typical hydroid with open mouth and tube-like body which was able to float at the sea-surface by secreting an internal gas, lighter than water, at the extremity of its sac-like body *(Figures 15a, b)*. Shortly thereafter, the parent polyp began to bud off additional polyps with feeding mouths along one side of its external surface *(Figure 15c)*. These remained attached, thus forming a colony. The parent's body then became greatly inflated with gas, thus acting as a float to support the growing community, while the functions of feeding and digesting were delegated to the rapidly multiplying young polyps *(Figure 15d)*.

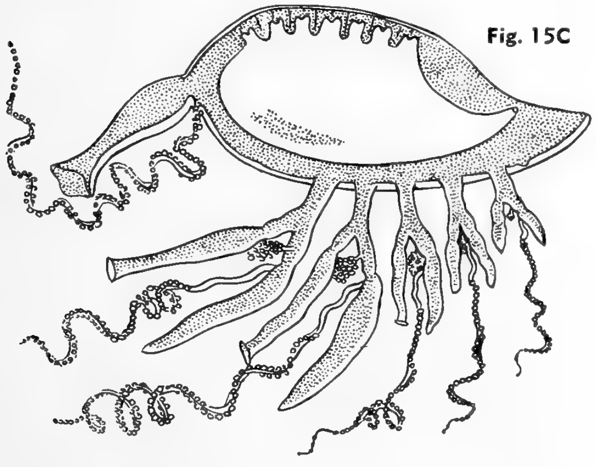
The secretion of the gas increased [illegible] grew larger, so that the supporting po[illegible] the float kept pace with the demands made upon it With each feeding-polyp a fighting or stinging individual budded forth. Some of these remained [illegible] while others, with their powerful bead-like batteries of sting-cells forming a close-set border along their entire margin, elongated to extend for down into the depths of the sea, alternately stretching out to their full length and contracting in tightening coils to bring the captured prey close up within reach of the now multitudinous greedy mouths *(See Figure 14)*. By the time the sensitive palpons or feeling polyps and the clusters of reproductive gonads had matured, the Portuguese Man-of-War colony had greatly increased in size and weight, but was always adequately supported by the enlarged float.

This latter is a remarkable structure of great beauty. It is essentially a large thin-walled sac, eight to ten inches in length in adult specimens. In some individuals, its thin, translucent walls are brilliantly colored, with rich crimson and intense violet hues blending into each other imperceptibly. Others grade from red to bright green. It is boat-shaped, with pointed prow and stern, and somewhat resembling a medieval caravel, while its thin walls are equipped with flat, transparent muscle bands the contractions of which continually cause it to change its shape.

A chambered crest adorns its summit and the protean changes of its outline enable it to trim sail and head into the wind.

Small fishes are stung to death and captured by its tentacles, with the exception of one species, seen in Figure 14, the Portuguese Man-of-War Fish *(Nomeus gronovii)*, which is apparently immune; for it swims freely among the deadly appendages without injury. This seems to be a commensal association of benefit to both organisms, for it is said that the fish acts as a lure, attracting other species

Figure 15C (Below) *As the colony grows, new polyps bud forth in clusters, each of which includes a feeding polyp, a feeling polyp, a reproductive polyp and a long fighting polyp or stinging tentacle*



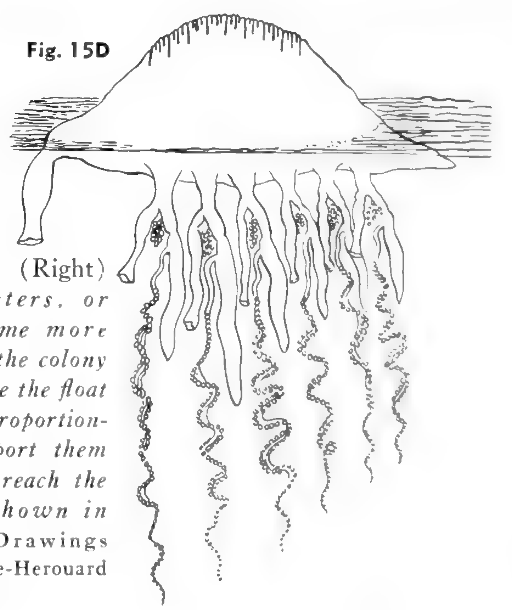


Figure 15D (Right) *These clusters, or corms, become more numerous as the colony matures, while the float increases proportionately to support them Finally they reach the condition shown in Figure 14* (Drawings after Delage-Herouard and Haeckel)

to their doom, while in turn it is sheltered from its enemies and perhaps shares the results of the capture.

In siphonophores like *Circalia stephanoma (Figure 16)* the float is reduced to a terminal bulb which barely keeps the colony at the surface of the ocean. This species, however, is equipped with an additional series of polyps, the swimming bells, which are umbrella-like structures surrounding the float in a circle. By their rhythmic contractions they assist in keeping the community at the surface and propel it through the water. A circle of feeling polyps projects just below the swimming-bells, overhanging clusters of male and female reproductive individuals. A single large feeding polyp hangs downward from the center, and interspersed among the other structures are numerous small stinging tentacles. The most important aggressive organ is a huge, branched, stinging tentacle that extends far downward from one side of the colony to trail its deadly nettle-cells far below. Other forms related to this, such as *Nectalia loligo (Figure 17)*, have a double vertical series of swimming-bells below the diminutive float, while a set of protective "bracts" or covers hangs down to protect the underlying organs.

Still other species, among the endless varieties of forms composing this protean group, are without floats and depend entirely on swimming-bells to keep their colonies near the surface. In some cases a single swimming individual is sufficient for this purpose (Monophyidae), as shown in Figures 19a and b, while others have two bells, one below the other (Diphyidae), Figures 19c and 20. These colonies trail the other component members behind them in successive clusters attached to a long filament like a tail.

Each cluster (cormidium) is composed of a protective bract enfolding the base of a small group of individuals, including a feeding polyp, a feeling polyp, reproductive gonads, and a long branched stinging tentacle. Some of these are developed to an enormous extent, forming complicated colonies of great delicacy and beauty.

In this remarkable group of the hydroids, based upon the plan of a simple tubular polyp, Nature has evolved an infinite variety of species of all gradations of complexity, and in the process has solved certain basic principles, such as colony formation, alternation of generations, division of labor among specialized individuals, and the coöperation of different species for mutual advantage. These achievements attained in this lowly group have made possible the development of important features of structure and function in the evolution of the higher groups in the animal kingdom.

Fig. 16

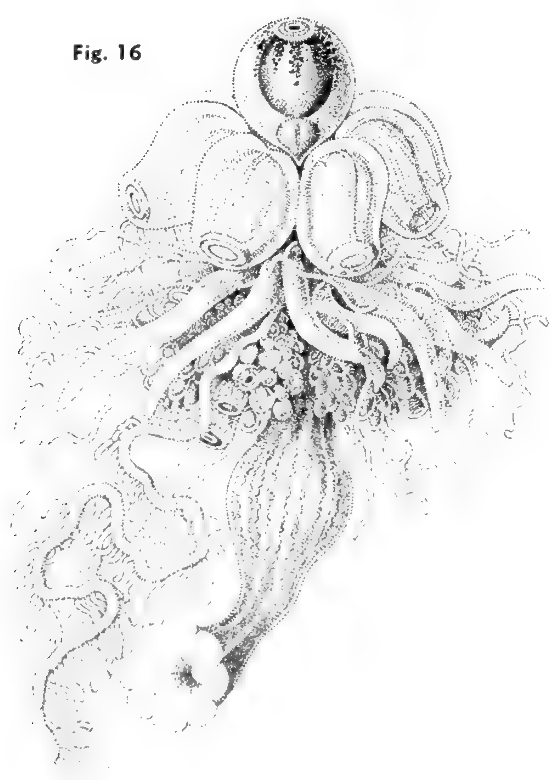


Fig. 17

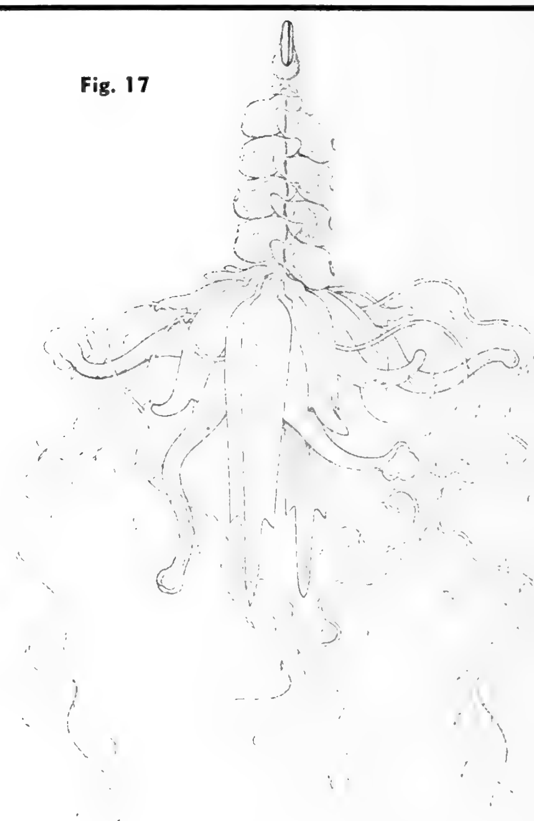


Figure 16. *In* Circalia stephanoma *the float is much reduced, but the colony swims by means of contractile "swimming bells"* (Redrawn from Haeckel)

Figure 17. Nectalia loligo *shows the float further reduced, while the swimming bells are more developed* (Redrawn from Haeckel)

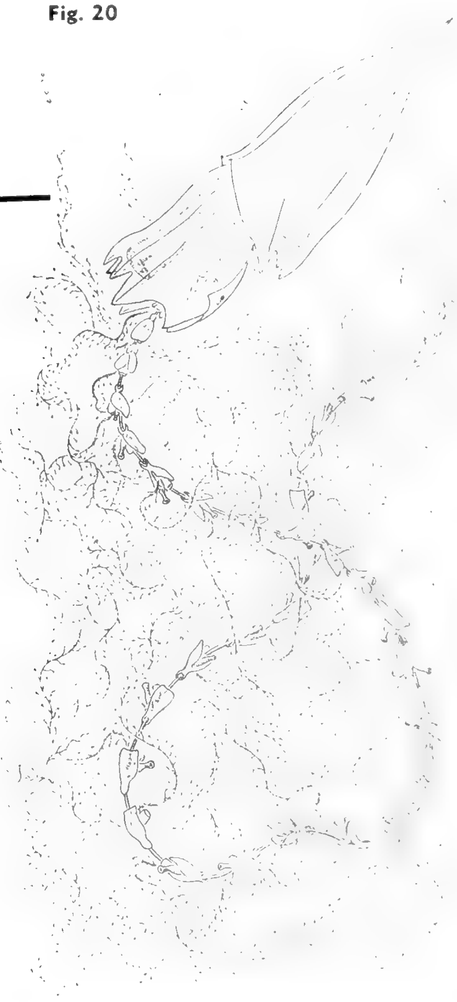
Figure 18. Athoria larvalis, *with diminutive float, has bracts terminating in swimming bells to support its colony clustered around the single large feeding polyp* (Redrawn from Haeckel)

Figure 19. *In* Sphaeronectes (*a*) *and* Ersaea (*b*) *the float has disappeared. They swim by means of a single powerful contractile bell.* Diphyes (*c*) *has two such bells* (Redrawn from Mayer)

Figure 20. Diphyopsis *with two bells trails a magnificent series of corms each bearing a set of specialized individuals* (Redrawn from Haeckel)

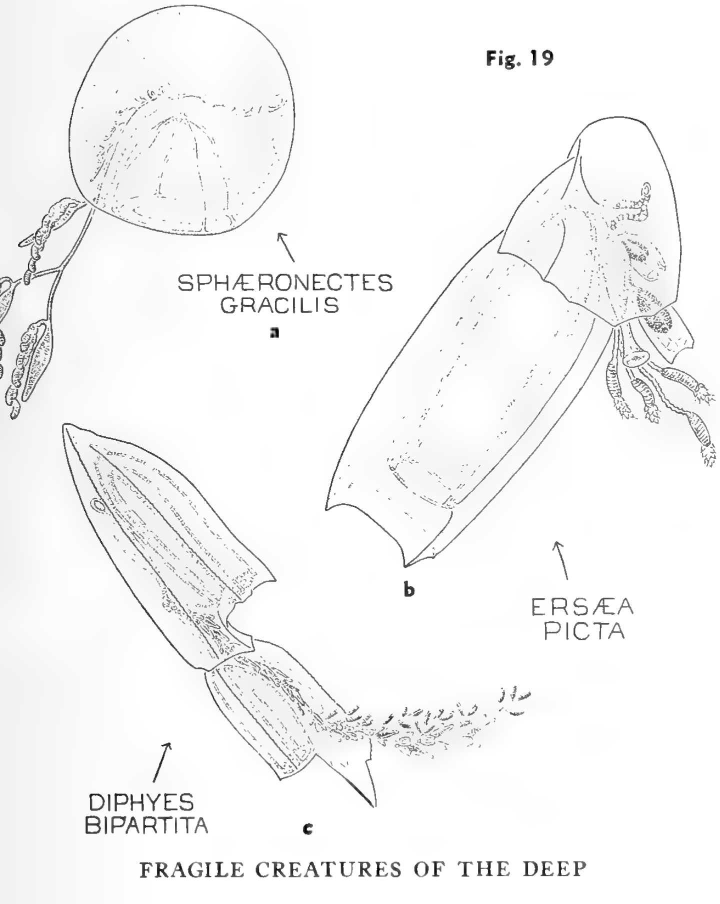
Fig. 18

Fig. 20



DIPHYOPSIS
CAMPANULIFERA

Fig. 19



MASTERPIECES OF PRIMITIVE SCULPTURE

By George C. Vaillant

THE AMERICAN MUSEUM OF NATURAL HISTORY

MASTERPIECES OF PRIMITIVE SCULPTURE

BY THEIR ARTS YOU SHALL KNOW THEM

By GEORGE C. VAILLANT

Late Director, University Museum, University of Pennsylvania

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The American Museum of Natural History

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BY THEIR ARTS YOU SHALL KNOW THEM

AMNH Photo

1. TIGER-FACED deity mask (Olmec) from Central Vera Cruz

Whether it be fear of the supernatural typified in the eerie carvings of Polynesia, the gaudy ritual of fantastic New Guinea masks, the astonishingly modern impressionism wrought on an African elephant tusk, or the subtle naturalism of clay sculpture in ancient Mexico—each primitive art tells the essential story of the community that produced it

By GEORGE C. VAILLANT
Late Director, University Museum, University of Pennsylvania

ART is a common denominator in all types of human culture. The greatest artistic achievements are still made by hand, so that the element of machinery, which so distinguishes modern Western Civilization no more affects the production of our modern arts, except perhaps architecture, than it does those of earlier eras. However, the social background of our modern art is very different from that of earlier and less complex tribes and nations. Whereas these simpler groups produced their arts in terms of craftsmanship, in our Western Civilization we confine such creative impulses to a small proportion of the population, whom, as "artists," we maintain as a special part of our social and economic structure.

Our attitude to our own artists is also affected by the extreme complication of our social organization. Simpler tribal communities often maintained skilled craftsmen by virtue of their artistic production, even as we do our own people with superior talents. On the other hand the universal primitive dependence on hand-work makes the cleavage between especial talent and ordinary skill seem less profound than in our modern communities.

The tendency of our artists and designers to draw inspiration from the arts of other peoples in other climes and other times may be due in part to this communal poverty in artistic expression and in part to the specialization implicit in a highly skilled profession. The fact that our modern use of the word "Art" has added to the term special shades of meaning not to be found in most languages may be also symptomatic of this general movement away from group participation in the creation of art forms.

Yet, if we moderns do not produce communal arts, we do show a wide interest in the achievements of other peoples, who have not lost their manual skill through complete dependence on machine production. Representative of this inter-

Photo by Hess

2. (*Left*) Not a nightmare Buckingham Palace guardsman, but a New Ireland native's concept of a supernatural being. The (to us) repellent effect should be overlooked in favor of the skillful carving and the insight it gives us into this people's awe of powers of Nature

All maps by Levett Bradley

AMNH Photo by Kirschner

3. The close association between community attitude and the shape and matter of community art is shown in the examples above, left and right. Beneath the painted clay face (*top*) is a human skull used by the New Guinea artist as a manikin. Note weakness of chin due to discarding skull's lower jaw. Even more lugubrious is the Maori head-hunter's art (*left*). Here is the ultimate in "naturalism." This human head solemnly and ingeniously preserved had the elaborate color design "chiseled" rather than tattooed into the skin during life. Both forms betray a realistic interest in The Head as against the bird-beaked figment of an Easter Islander's fancy (*right*) which suggests imaginative mysteries. All these forms are distinctly alien to the western mind

AMNH Photo by Kirschner

Photo by Hess

est on our part is the art museum, an element of popular instruction and gratification, only recently introduced into our social economy. Here we may see sculpture, painting, and other works of art carefully selected according to our own ideal of beauty and the historical development of this ideal.

The art museums carefully distinguish the more modern works as to their creators, but they can only designate the period and place of origin of the earlier masterpieces. Moreover, this anonymous art of the past often has a religious or utilitarian purpose, whereas the most recent identified works seemed designed for purely aesthetic ends. The relationship of the ancient religious arts to our modern aestheticism can be readily seen, and from the point of view of appreciation or intrinsic worth, the past does not have to bow to the present.

The majority of the art museums, for reasons of public taste, space, and finance, direct their exhibits with a view to their relationship to our present culture. There is a very obvious tendency to broaden the historical and comparative base of our modern art. Examples of Egyptian, Chinese and Cambodian art enhance and expand the view of aesthetic achievements of mankind. Yet there are many important and interesting schools of artistic expression that cannot be included in the museums primarily formed to show art.

These developments, however, are not inaccessible. They are collected and exhibited in anthropological museums, whose purpose is to show the Natural History of Man and whose exhibits are frequently combined with those of Natural Science, as in the American Museum of Natural History. Since anthropology occupies itself with the biological, social and technical processes by which man has been able to live in every part of the globe, the art of man appears as an aspect of his general evolution, not as a subject in itself. By a sort of informal consent these collections stop with the dawn of civilization, whereupon the art museum takes up its phase of the story and the museums of science and industry or history display the other phases of cultural evolution.

It is obvious that this cleavage is artificial. There is much material of anthropological importance in a major art museum and many fine examples of art in a museum exhibiting the natural history of man. Yet, the difference in manner of display and emphasis tends to divide the two types of museums as well as the interests of their visitors. To reconcile this apparent divergence the American Museum of Natural History has set up an exhibition to stress the notable achievements of peoples whose arts were not tributary to the main stream of European civilization, and consequently are not represented in museums illustrating the art history of our culture.

Skill in depicting the human form and in suggesting its spiritual essence is an important index to the artistic achievement of mankind. Even as man originally created his gods in his own image and endowed them with his own attributes magnified and intensified, so in making images to revere and to symbolize, man tried to reproduce the human form. Thus in these outlying zones of human culture, sculpture becomes an excellent means for comparing the native arts with our own highly defined artistic conceptions. The formulae of presentation, the ultimate synthesis of the physical type, the hauntingly intangible reflections of the group psychology, all lead us into fascinating fields of contemplation. A study of pure design, if more directly comparable, is too cold to challenge the imagination as does sculpture. This point will become more clear when we consider the tribal carvings we have selected as illustrative of the high development of arts outside of our own tradition.

Easter Island

Isolated in the limitless expanses of the Pacific, Easter Island is the source of an important sculpture in wood and stone. The wood-carving combines three features, a religious purpose, a naturalistic presentation and a firmly established style. The figures represent either old men or elusive beings with heads of birds. They seem to be designed as portable idols, since they do not stand without support, and disclose the delicacy of detail and subtle gradation of surface planes requisite to an object designed for handling. In contrast to the wood-carving, the massive heads and torsos, made from huge blocks of lava ranging up to 30 feet tall, appear rude and uncouth, but symbolize, nonetheless, the power of the supernatural so dominant in primitive life.

We cannot recapture the precise attitude of mind of these carvers in wood and stone, since forcible removal of the population in 1862 destroyed the native culture. However, technically and stylistically Easter Island art fits into the general pattern of Polynesian sculpture. If the forms are perhaps ancient in concept, they are not

of any tremendous antiquity. However, contemplation of these carvings from our own emotional and intellectual plane discloses an eerie quality, fitting to the religious art of a people isolated in the midst of a limitless sea.

New Guinea

In contrast to the austerity of Easter Island sculpture, the art of New Guinea discloses a barbaric panoply of ritual. Intricate design, bright colors, fantastic masks, complexly stylized idols, create a rich pageant to absorb the tribal interest. Ceremonies for initiates, ceremonies for uninitiates, ceremonies bought, and ceremonies sold, involved a mass participation in plastic and decorative expression, productive of an astounding array of highly decorated paraphernalia. While individual examples or even a large number of specimens, hastily seen, might well induce the effect of an exuberant lack of restraint, closer study reveals an adherence to stylistic canons and to forms of presentation, that indicate a long tradition of expression. In its broadest aspects this wood-carver's art radiates through the Melanesian islands, each of which has its distinctive tribal styles. Its past may extend even to the early culture of the Asiatic coast.

Such art as this is difficult to harmonize with our west European canons, but in a decorative sense, one could easily conceive how the very intricacy of a New Guinea carving would relieve the rigorously mathematical lines of our most modern interior decoration. Although we may reject these styles as bombastic and outside of our tradition, Melanesian art is a distinctive, expressive, and calculated result of centuries of practice under a well-defined, if unverbalized, æsthetic.

Utilization of Natural Forms

The direct principle of reproducing natural forms seems stifled in the midst of this rampant Negroid development of design. Yet the treatment of human skulls discloses a plastic sense that stands out from the rest of the art. The skulls were covered with clay, which was then carefully modeled with an accuracy suggestive of actual portraiture. The ultimate end may have been magical or ritualistic, but the result is a noteworthy sculpture. All too often, the skillful building up of the features is lost through the application of paint, which, although reproducing the appearance of a living subject, nonetheless obscures the essential excellence of the modeling.

In contrast to this plastic art, based upon headhunting, is the Maori custom of carving and dyeing beautiful designs upon their faces during life. After death the heads of notables were smoked and carefully preserved. The process brings out the design and shows how exquisitely the elements of the pattern were gauged to conform with the position of the features of each face.

Both of these methods of using the human head as a background for artistic expression far surpass a third variation found in the Amazon drainage of Ecuador and Peru. Here the head of a victim is skinned and the hide reduced by heating and drying. Manipulation of the skin retains the main contours of the face and the adornment of the head with colored feathers and insect wings discloses an interest in ornament. Yet the total result is crabbed and wizened, hardly to be compared with the superb techniques of the Pacific Islands.

West African Art

The art of Africa evokes from us moderns a more direct response than do these styles from the Pacific. African sculpture seems to express the lusty emotions of the Negro, and conforms to the sensory appeal of our European tradition. Perhaps because of its greater familiarity to us, perhaps because of its emotional content, African art does not have that strangeness of presentation and function that blocks our approach to many of these distant arts of obscure peoples. While all Negro carving has a generic resemblance from the point of view of Europe, familiarity with the subject will disclose many tribal and regional styles. In all of Africa, the west coast has produced the most exciting developments, the bronze art of the Benin region and the ivory sculpture of the Mangbetu people.

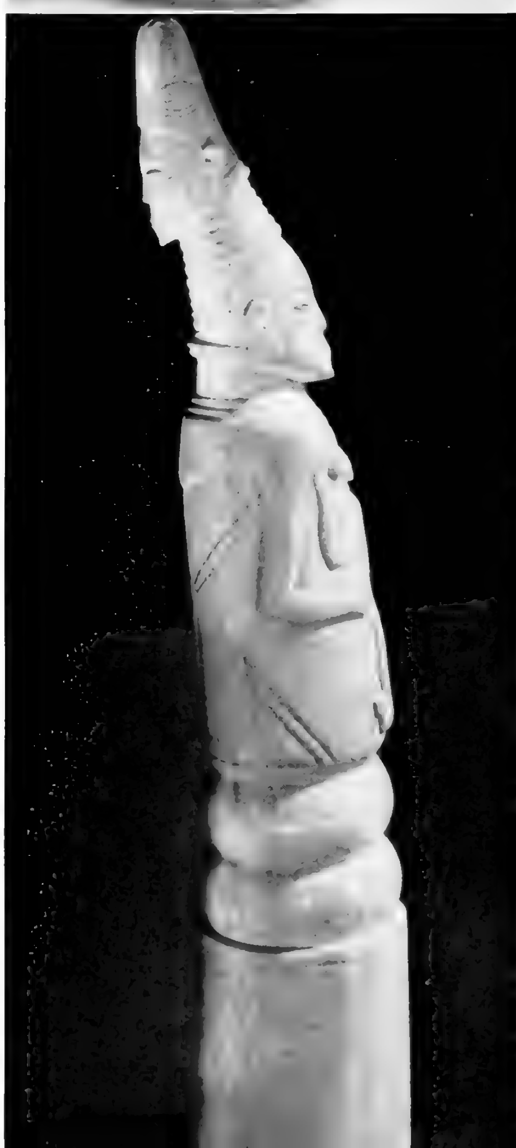
The Benin bronzes fulfilled the needs of church and state as did the medieval art of Europe. This strikingly rich fruition of Negro genius has a bold realism, fitting in those west coast kingdoms, where killing, cannibalism, polygamy, drunkenness, and, above all, pomp prevailed. The casting of the bronzes by the lost-wax process may have been introduced by Europeans, but the expression and the styles have no hint of influences alien to the Negro. The heavy pride to be seen in photographs

4. (*Left*) AFRICAN ART, with its many ardent devotees among us moderns is generally more appealing to our emotional temperament than the work of any other primitives. Somewhat paralleling our feelings about African as opposed to oriental music, it seems lustier, earthier, more stimulating than other more decorative arts. Down center of page are two items in a Mangbetu chief's royal treasury. Both are beautifully incised ivory pieces curiously possessing the abstraction of form sought in much modern sculpture. Upper figure is girdled with a kind of pictorial frieze, while the graceful taper of the lower one is controlled by the tusk's shape

Photos by Hess

5. (*Below*) BENIN BRONZE is the alliterative catalogue name for this collector's piece and indicates the traditional medium of the Benin tribe of West Africa. With this alloy they fulfilled the needs of church and state much as did the art of medieval Europe. Students comparing the two also point out that both forms show the strict subordination of individual expression to that of the group, a quality our modern art has all but lost

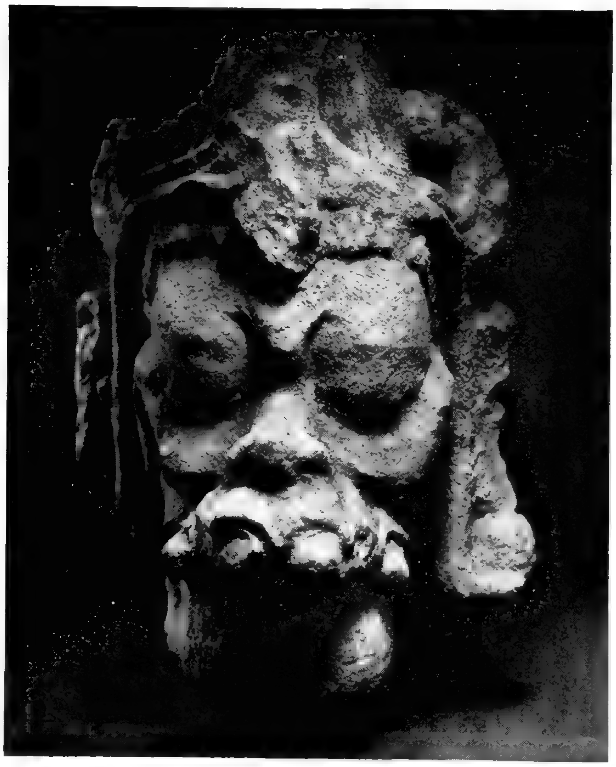
AMNH Photo by Kirschner



6. (*Below*) SOMEWHAT MORE ELABORATE is this Congo-made head, a striking ornament attached to no more exalted a base than an ordinary clay pot. Notice the skillful execution of the features. This together with the care expended to work up a metallic surface sheen seems a prodigal waste of talent to us, accustomed as we are to machine produced utensils

AMNH Photo by Kirschner

7. (*Above*) AN ABORIGINAL "CHERUB"; typifying the highly humanized Totonac art of what is now the state of Vera Cruz (Mexico). Relics of pre-conquest days in this region often show a whimsical likeness to Chinese art, doubtless enhanced by the depiction of the Mongoloid features so common in American Indians. Humor, like that so clearly defined in this clay piece, is a rarity in New World art generally and seems restricted to this area. Though nearly as pleasing to the modern eye as African works, Middle American sculpture might be more esteemed were we not unfamiliar with baked clay as a medium for major works of art



AMNH Photos by Kirschner

8. (*Above*) TWO MAYA MASTERPIECES which once looked down from the walls of a sacred temple. The symbolism of an established tribal ritual looms large in the one at left with its grotesque features, but the excellence of the naturalism in the other has the appeal of a great world art

9. (*Left*) THIS GOD'S MASK from the Tabasco region displays an unusually sophisticated style as well as the expected religious stylization so prevalent in art designed for community expression. Plaster masks presented in this same way adorned the walls of the earliest Maya building yet discovered by archeologists

Photo by Hess

of west coast kings is transposed to these bronzes and the accentuation of the wide, low, thick features reveals the artists' understanding of the way to visualize the essential character of the tribal psychology. As befits a national art, there is an inherent monumental quality indicative, not of the individual artist, but of the æsthetic influencing the whole tribe. The production of this tribal art was a craft, not an embodiment of an individual's perception, and we notice in the arts of the Middle Ages, although the traits stressed are less full-blooded than the African, the same obliteration of individual reaction in a great mass expression.

The Mangbetu ivory treasure is probably the last coördinated output of a West African kingdom. The firm hand of colonial administration plus the drying up of the ivory supply combine to extinguish the full development of a national art. The social background for the creation of this ivory sculpture was much the same as in Benin, but the gleaming white of the medium employed gives a less lowering effect than the blackened bronze of Benin. Elongated forms, controlled by the shape of the elephant tusks, have a gracility lacking in the bronzes. Ivory also provides a natural surface for drawing so that the graphic arts are represented in a lively and expressive manner, although less grounded in the traditional forms of the sculpture. In this Mangbetu art, craftsmen, working in a tradition, served religion and the coast and created a closely coördinated artistic expression that permeated a wide variety of forms. Even as the arts of the Middle Ages, this African æsthetic reveals unity but not repetitiousness in its richly varied application.

Occasionally, the element of pure realism breaks the bonds of custom and exquisite forms result. Two superb clay heads from the Yoruba country will rank with great portrait heads of any civilization. African art, because of its vitality, will stand high in the scale of tribal and national arts. Our familiarity with the racial types involved and our comprehension of Negro emotional values bridge the gap between African presentation and our own. Therefore, African art makes an excellent point of departure for the understanding of arts wherein a distinctive set of racial and emotional factors are involved.

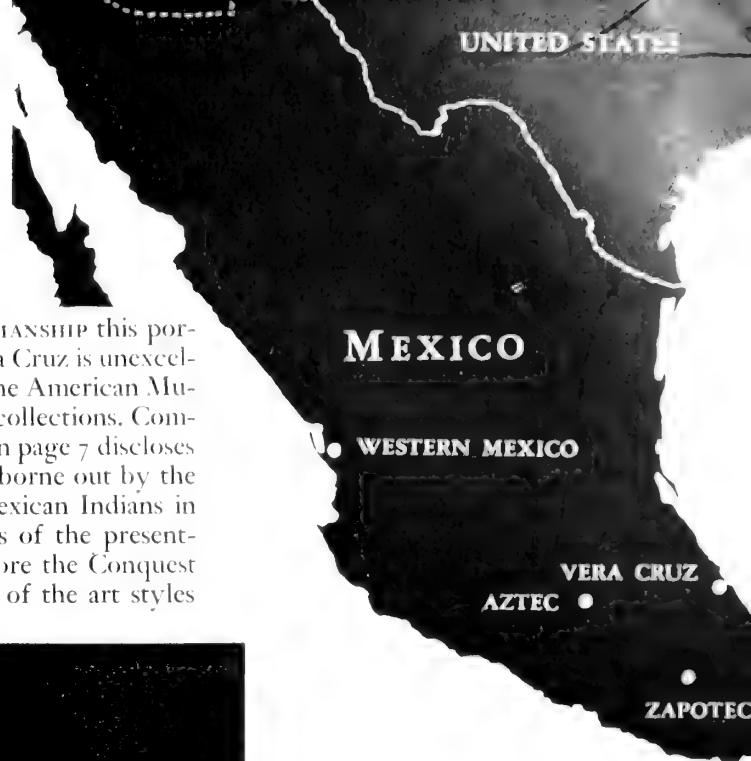
New World Art

The art of the American Indians passes through the full range of artistic evolution. All stages are represented from the highly sophisticated products of highly ritualized civilizations to the crude linear patterns of people almost on the threshold of human living techniques. Yet this rich and complex field for observing not only the fulfillment but also the formation of artistic expression, is virtually unknown to the world of art. Three factors have been instrumental in barring a popular esteem for our aboriginal continental art: it is exhibited in the custody of anthropology; much of the subject matter is highly ritualistic; we lack an emotional understanding of the Indian character and, therefore, his art, so that the subject matter of his æsthetic seems cold and abstract.

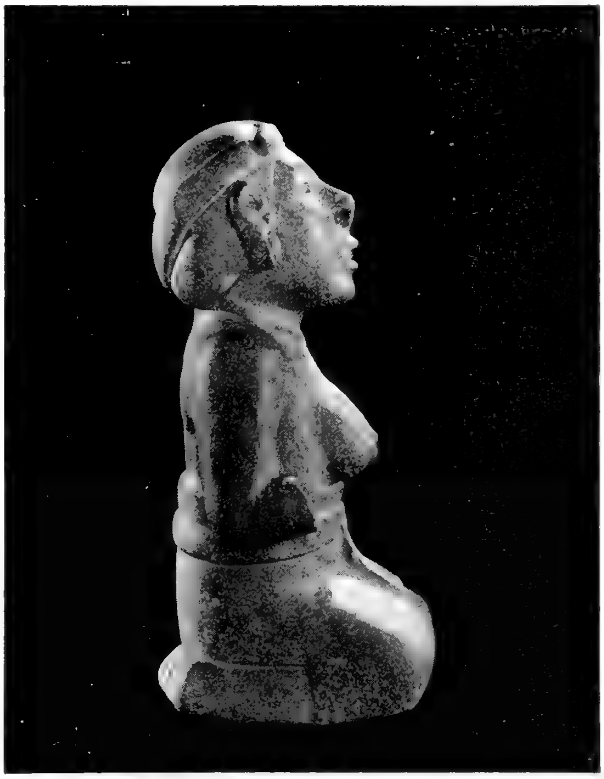
Our western civilization has as a goal the comprehension and the subjugation of nature. In our modern art, we see efforts to recapture and transmit a person, a mood, a truth, or an attitude. The Indian tried rather to establish a magical relationship with nature, wherein, although recognizing the superiority of natural forces, he could constrain or induce them to act in his favor. This attitude persisted even in the highest Indian civilization where magic was transformed into a complex ritual and the tribal surplus was converted to the maintenance of the religion. The service which art has always rendered religion was not neglected in Mexico, but it progressed along the lines of symbolism and ritualistic detail. Thus in content and in presentation, Middle American art is antagonistic to our method of contemplating the universe. However, it is possible to select out elements of Middle American art which can be appreciated intelligently against our own background.

Maya Art

The ceremonial art of the Maya-speaking peoples stands supreme among these ritualistic developments. Every line, every contour, every minor symbol bespeaks tradition and method. Yet the Maya gods were often human personifications of natural forces and in representing them Maya craftsmen reproduced their ideal of beauty. At Copan, in Honduras, during the middle centuries of the first millennium after Christ, a remarkable sculpture in the round was dedicated to this end. The deformed forehead, large nose, astigmatic eye were stressed as important indications of beauty. As would be the case in depicting a fattish people, the contours of the face and body were stressed,



10. (*Left*) For sheer craftsmanship this porphyry mask from Central Vera Cruz is unexcelled by any single art work in the American Museum's vast Middle American collections. Comparison with the Maya heads on page 7 discloses a latent strength in this piece, borne out by the ruggedness of the modern Mexican Indians in contrast to the gentle softness of the present-day Maya. Indian history before the Conquest bears out the mute testimony of the art styles

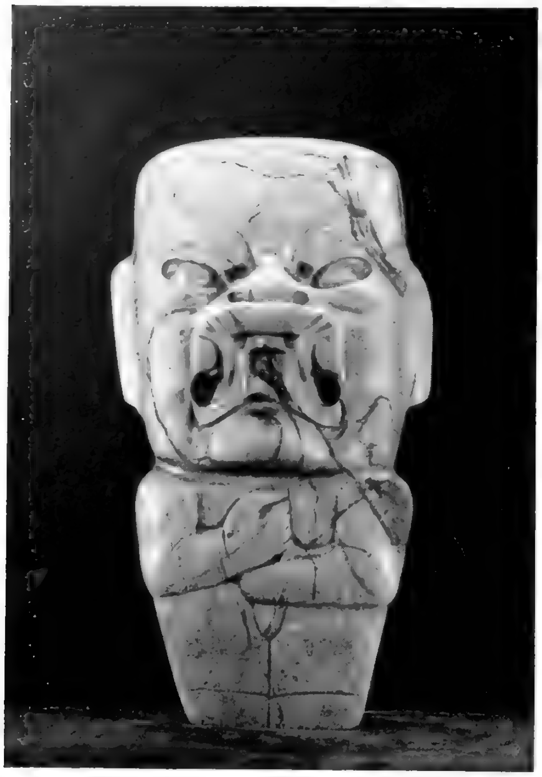


11. (*Right*) Corn goddess of the Aztecs carved in basalt. The idea of ripe maidenhood suggested by growing corn is one of the many poetic conceptions which primitive people have applied to their staple food-plants

AMNH Photos

12. (*Left*) Large clay figure unearthed from an ancient grave in western Mexico. Despite this association with the after world, the comparatively naturalistic treatment of face and body denies that its creators were enslaved by ritual. But one glance at the fantastic Zapotec sculpture at right reveals the work of a people given to the intense ceremonials of a Middle American theocracy. Resembling the many-armed gods of Tibet, this piece does not require experts to point out how the requirements of the local religion had narrowed the range of artistic expression

13. (*Below*) MORE PRECIOUS THAN GOLD from every standpoint was the native American jade from which this beautifully carved ceremonial axe-head was created. The face is that of a deity widely worshipped under various names, who was conceived as having the face of a jaguar or ocelot (large leopard-like feline). Below at right is the head of a Vera Cruz idol wrought in baked clay, a medium favored for the subtlety it permitted these early artists who lacked effective metal tools



AMNH Photo

Photo by Hess

rather than the anatomy, and the polishing, pecking, and grinding processes necessary in working stone without metal tools would accentuate the sculptors' interest in surfaces. The Copan stoneworkers succeeded in producing figures which have an aloof repose, fittingly recording the power incarnate in nature. Moreover, these figures were meant to be seen from below and the faces of these gods look down dispassionately upon their worshippers.

The Art of Vera Cruz

An abundance of fine sculpture comes from central Vera Cruz in Mexico and it is easily assimilated in terms of our western æsthetics, for Totonac and Olmec art gives a tantalizing suggestion of Chinese forms, an impression heightened by the skillful reproduction of the Mongoloid features, commonly found in our Indian population. The Totonacs and the Olmecs not only worked in stones ranging in hardness up to jade, but also utilized baked clay as a medium for expression. The latter substance, so subtle and so easy to manipulate, seems to have been neglected by most Old World civilizations as a material for major work of art. Yet its extensive use in Middle America as a medium for major plastic expression may be a result of the absence of the sharp-edged metal tools, essential for woodcarving. In fact, our aversion to this material in our own art causes us to discount some of the most important Middle American art.

The variety which the Olmec and the Totonac attained in their clay sculpture extends to differentiations of physical type, distinction between ordinary and supernatural beings, and even to distinguishing facial expression, and definitely reveals the presence of versatile and sensitive craftsmen. Yet these workers also could combine the abstract designs of a stone ceremonial yoke with an ele-

14. The most advanced art developed by the North American Indians was the work of the tribes occupying the coasts of British Columbia and southern Alaska. At left is a horrendous monster of mythological significance to its Kwakiutl makers, which contrasts with the lovely Haida girl's face below. The modeling of this mask so vividly recalls a living person that portraiture is suggested

All photos by Konrad Cramer under a grant from the Rockefeller Foundation to the Museum

15. (*Below*) This Kwakiutl mask is intended to show two separate personages. The open wings close to represent another embodiment of the same spirit. Vivid coloring plays an important role in characterizing the mythological being. The colors are used symbolically rather than to enhance the æsthetic values. (*Below right*) No example from the Northwest Coast in the Museum's collection can touch this Tlingit helmet for sheer power. It depicts the warped features of a paralyzed old man revealing an irritable contempt instead of mawkish self-pity

gantly chiseled profile of purest realism. They could create the chuckling merriment of a laughing head in clay and reproduce a warrior's stern features in porphyry. Another group of clay sculptures recalls the fatigued sophistication of the Ptolemaic art of Egypt.

Arts like these are comparable on direct terms to the great national expressions of the Old World. The jades from southern Mexico rival in sheer intrinsic values of color and design the long-admired jade art of china. Yet there is no doubt of the independent evolution of these two arts.

Aztec Art

The Aztecs are the best known to us of the Middle American peoples. The Spanish conquerors, military and ecclesiastical, studied them carefully, for they represented the full tide of Indian culture at the coming of the whites. Aztec art exemplifies the ceremonial representation of Middle America, enhanced by the balance and rhythm of the profound sense of design, almost universal to Indian art. Yet, given a reason, Aztec craftsmen could reproduce, with singular charm, goddesses who had for them the connotation of youth and spring. The validity of Middle American presentation is amply attested by the works of Diego Rivera, who was the first of his countrymen to thrust away the canons of European bodily proportion in order to portray the anatomical and spiritual qualities of the Mexican Indian.

The peoples of western Mexico never attained the high degree of civilization reached by their eastern and southern neighbors. Their art, expressed chiefly in clay, is intended to represent but not to symbolize. Both people and animals are represented doing things, although not in violent movement. This passiveness, a sort of monumental inaction, runs through Mexican Indian art, and the modern visitor notices that same lack of violent emotional expression in the present native population. At first oppressive, the effect becomes soothing and calming, counterbalancing the violence of thought and deed in our western world. Equally characteristic of the old Mexico and the new, is a sly, quiet humor which peeps out of the rigors of ceremonial expression even as it bubbles quietly among the modern Indians repelled so far from their once proud state.

North American Art

The North American Indians seldom reached the great heights of ritualistic expression attained in the Central American civilizations. While the builders of the mounds in the middle western and southeastern United States show evidence of considerable artistic ability, for sheer exuberance in design and sculpture the carving art of the Indians of the Northwest Coast stands supreme. Wood was the great medium, and it is tantalizing to think of how little we would know of this art had it not flourished in the latter half of the nineteenth century. Not only do these tribes show the innate Indian ability to use conventional representations in exquisitely designed combinations, but also they produced in their masks, especially, a naturalistic sculpture of startling power, ranging from the sympathetic depiction of a young girl to a medicine man portrayed in the depths of a trance. The bulk of material indicates a tremendous conversion of technical talents to the service of art.

In viewing primitive art, one sees the work of the skilled craftsmen of many nations, tribes and communities. There is a unity to each of these communal expressions of man's search for harmony and beauty. An individual who cannot afford the great masterpieces of the western world may find great content in collecting these minor works of art in accordance with the dictates of his own æsthetic conventions. Another, weary of words, of theory, of propaganda, may find a peace in the feeling of common endeavor which these arts produce, without the accompaniment of torrents of verbalized learning. Despite the individualization of western art, in practice one can pick out the schools, the culture groups, just as among these anonymous arts of forgotten people. If this exhibition means nothing else, it shows that art is a people's common heritage, a field in which all may participate. Let us not let our tendency to specialize and to delegate turn us away from fruitful, active interests for the sake of a sterile admiration of technical superiority.

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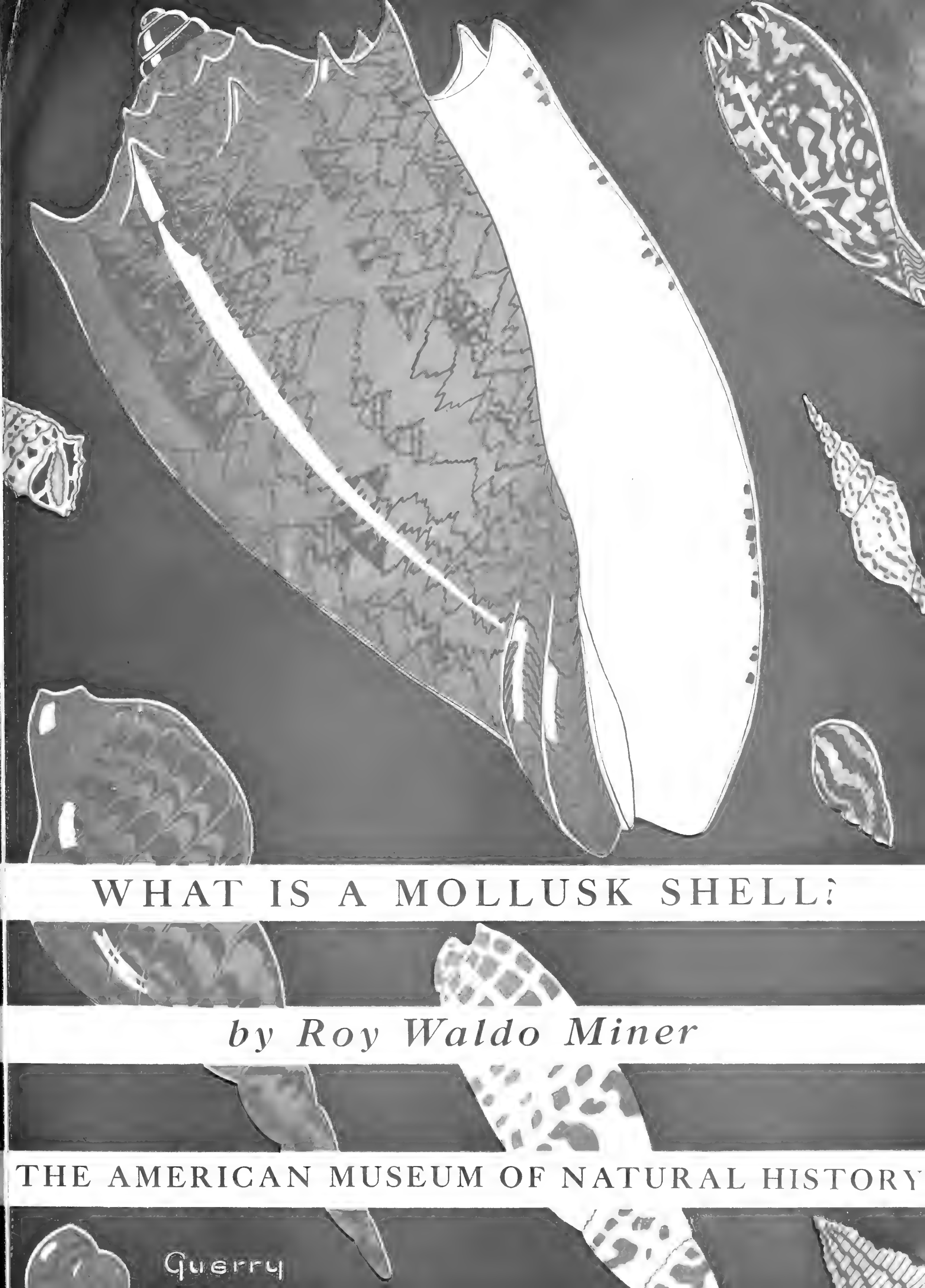

WHAT IS A MOLLUSK SHELL?

by Roy Waldo Miner

THE AMERICAN MUSEUM OF NATURAL HISTORY

Issued under the direction of the
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Roy W. Miner,
Chairman.

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GUIDE LEAFLET SERIES

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What Is a Mollusk Shell?

By Roy Waldo Miner
Curator of Living Invertebrates

Mollusk shells have always been of great interest to collectors. Because of the great number and variety of species, the remarkable diversity of form, color, and size, they have always attracted popular interest and have been fertile sources of motifs to students of design.

From the zoölogical viewpoint, the mollusks are one of the most important groups in the animal kingdom. Next to the insects they include more species than any other animal subdivision, approximately 80,000 being known. The phylum containing them is quite distinct from any other modern group, though the most primitive forms and the free-swimming larvae seem to point to an origin close to that of flatworms or platodes.

Paleontologically, they are one of the oldest groups, representatives being abundant among the fossils of the Lower Cambrian strata laid down at least 600,000,000 years ago. Their shells alone are preserved in a fossil state, but their abundance and the relatively high organization of all mollusks seem to indicate that they existed for millions of years previously, perhaps as naked forms incapable of leaving traces of hard parts in the rocks. It seems likely that the comparatively acid seas of early Pre-Cambrian times when the oceans were more or less free from the salts that accumulated in later ages by erosion from the continents, made the formation of shells of carbonate of lime impossible. Later, when the seas accumulated much calcium in solution, shells were formed, perhaps at first as one of the by-products of excretion, and later utilized and perfected as a means of protection.

The shell is the secretion of the mantle, a thin fleshy fold of tissue that surrounds the upper part of the mollusk's body. As indicated above, it is largely of carbonate of lime, and is laid down as a deposit on a base of delicate horny substance produced by the animal, and spoken of as *conchyolin*. The limy portion takes the form of crystals of calcite or aragonite, standing vertically, or laid down as delicate scales or laminæ slightly overlapping one another. Usually, the shell is composed of three layers: an outer layer of horny integument, rough in character, or raised in hair-like projections in some shells, in others a rough or smooth porcelain-like layer of vertical calcite crystals; beneath this a second calcite or aragonite layer with the crystals laid in another direction; and finally a porcellanous layer like the first. Shells that have an iridescent or pearly lining are usually the more primitive species. In such cases, the two outer layers are very thin, while the inner pearly layer takes up the greater thickness of the shell. This is composed of thin minute plates of calcite arranged horizontally with their edges overlapping like tiny shingles. The light diffracted from the close set lines produced by these edges causes the iridescent effect. The substance of this layer is generally spoken of as *nacre*.

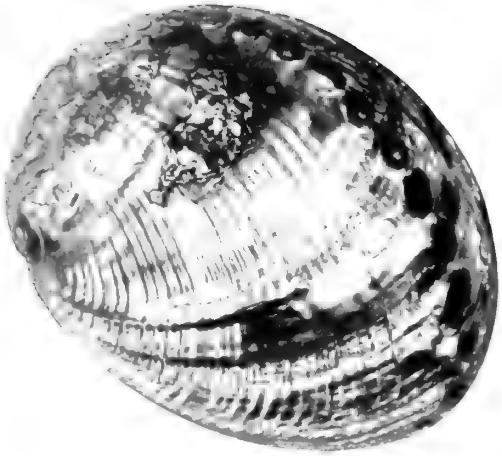
Though the shell is often the most conspicuous part of the mollusk and the part most easily preserved in collections, it is really only a by-product of the animal, and biologically of secondary importance. It bears about the same relation to the animal as a suit of armor bore to a knight of the Middle Ages. If all we knew of a human being were the armor remaining from that period, it would bear somewhat the same relation as would our knowledge of mollusks, if the latter consisted merely in our acquaintance with their shells. The conchologists of the middle and latter part of the Nineteenth Century brought together huge collections of shells from all parts of the world, and, during that time, shell-collecting became a craze and was often the avocation of wealthy men. But the scientists of the time studied shells seriously and with great ability, so that our knowledge of their infinite variety, structure, and distribution advanced enormously, and gradually many facts became known concerning the animals that produced them, as well as their anatomy and life history. Nevertheless the classification of mollusks was based at first almost entirely on their shells and many errors were made that were gradually corrected in later years, when our knowledge of their soft parts was increased. The present-day student of mollusks investigates the animal itself as well as the shell, and gathers all possible facts that will make our knowledge of this group as exact and exhaustive as possible.

From the economic standpoint, mollusks have always been of the greatest importance to the human race. The bivalves, or two-shelled mollusks furnish an enormous food-resource, while the gastropods or single-shelled, snail-like forms, as well as the squids and octopuses, have contributed their part, though to a lesser degree.

The oyster, clam, and scallop fisheries are by far the most important. Millions of dollars are invested in their development, and thousands of men and great numbers of vessels are employed. Mussels, cockles and razor-shells are also eaten, especially in foreign countries. Among the gastropods used for food in various parts of the world are periwinkles, whelks, conchs, and the luscious abalone.

(Continued on Page 14)

(Left) The Glory of the Sea (Conus gloria-maris). *Enlarged two diameters. This is the rarest and most sought after of shells. It is practically extinct as no specimens are recorded as having been seen alive since 1838, when Hugh Cuming of the British Museum found three specimens on a reef in the Philippines. Not more than a dozen specimens are known to exist and have always commanded high prices. There are two perfect specimens in the collections of the American Museum. The tapering shell suggests an unfolding rosebud. Its porcelain-like surface of pure ivory is completely covered with a mosaic of thousands of tiny triangular figures outlined in chrome-yellow or deep chestnut. Three broad spiral bands of orange encircle the body and, in certain lights, the whole shell is suffused with a faint rosy sheen. The specimen illustrated is five inches in length and was collected in the Moluccas*



A Series of Polished Ear Shells *(Haliotis sp.)*. The series of shells crossing the pages diagonally illustrates the varying surface character of different species of ear shells or abalones when the rough outer layer has been polished off

(Below) The Cameo Helmet Shell *(Cassis madagascariensis)*. This shell is not an inhabitant of Madagascar as the scientific name implies. This was due to a mistake of Lamarck, who named it. It ranges along the Atlantic coast of the United States from North Carolina southward and throughout the West Indies. It is one of the largest of our marine snails and was of great commercial value for cameo-cutting when those delicate shell-sculptures were the vogue. Now they are no longer in style and the demand for cameo shells is at an ebb. The shells were formerly exported to Italy and France where the white outer layer was cut into bas relief in skilfully wrought figures standing out against the rich dark brown background of the exposed inner layers of the shell. Ancient cameos were cut in semi-precious stones during classical times. It was not until the early part of the nineteenth century that shells were used for this purpose. The Queen Conch *(Strombus gigas)* was also used to make pink cameos on a white background

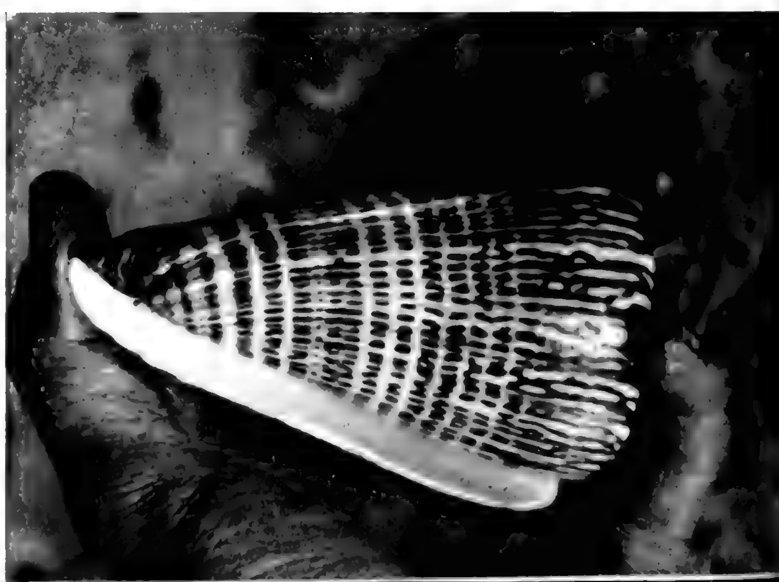
(Above) THE BEAR'S PAW CLAM *(Hippopus maculatus)*. This is one of the most graceful and fascinating of bivalve shells. It is native to the seas of the Far East, where it is abundant on coral reefs. Both valves are sculptured with a series of rounded and fluted ridges separated by alternating grooves curving over the highly arched shells. These are ornamented with rows of leafy projections and irregular bands of purplish rose rising over the pure white ridges and dipping into the yellow valleys between. The scalloped shell margins neatly interlock as they come together

THE POLISHED SURFACE OF THE ABALONE, as shown by the three diagonal photographs, may be wavy with scattered flutings, comparatively smooth, or thrown into fine parallel ridges. Note the differences in the curving of the spire. The color is a changing iridescence on a background mottled blue to peacock green, red and silver, and broken rainbow hues. The lines of the color markings make extremely interesting and often complicated wave patterns. These features are carefully utilized in cutting up the shells for commercial ornaments

(Below) The Famous Slit Shell *(Pleurotomaria beyrichi)*. This rare shell belongs to a genus once supposed [illegible] extinct, but since 1860 occasional specimens [illegible] dredged alive in deep water in the West Indies [illegible] near Japan. It is remarkable for the broad slit extending [illegible] around the outer whorl. As the shell grows this closes from behind. The trail of the closed slit may be seen extending around the spiral of the shell. This photograph (natural size) is of an unusually fine specimen richly colored yellow and red. Fossil specimens occur abundantly since the Cambrian, 600,000,000 years ago

(Above) The Bishop Cone Shell *(Conus episcopus)*. From the Pacific and Indian Oceans. The white, porcelain-like triangular markings are on a chocolate background. Like all cone shells it has a poisonous bite. A tapering proboscis contains two bundles of tiny hollow teeth, each with a poison gland. A painful wound may be inflicted on the hand that picks it up

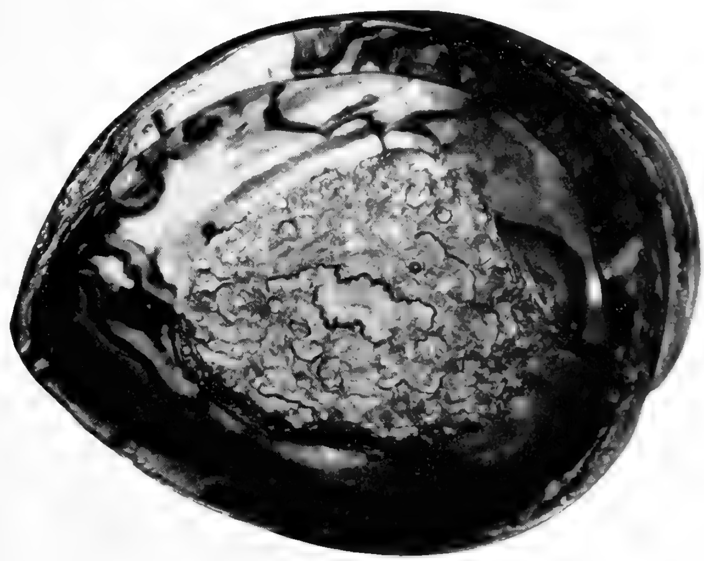
The Porphyry Olive *(Oliva porphyria)*. The olive shells have a much shorter spire than the cones and much more rounded shoulders. The outside is like polished porcelain produced by reflected folds of the gay mantle which adorns the outside of the shell in life. The surface in this species is covered with crowded tent-like markings in brown, so it is often called the "Camp Olive." (Gulf of Mexico)



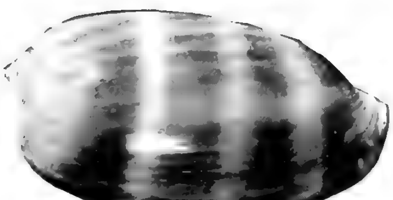
The Thousand-Dotted Cone *(Conus millepunctatus)*. This cone from the East Indies is completely covered with thousands of close-set brown dots on a white background. Because of their irregular arrangement they resemble characters of some inscribed writing. The spire is quite flat. It is one of the common cones of the Far East. The specimen represented is about five inches in length

THE SPLENDID ABALONE *(Haliotis fulgens)*. The abalones are also called ear shells because of their shape. There are many species of them found on rocky shores and distributed widely in California, Lower California, Indian Ocean, Australia, Japan and Africa, with one small species in Europe. They are remarkable shells, often of large size, the specimen here illustrated being eight inches in length. The outside is rough with a low coiled spire so that the shell looks like one valve of a clam-like mollusk. Nevertheless it is a true gastropod with but a single shell. The animal has a broad foot enabling it to cling closely to a rocky surface and is pried away with difficulty. The shell has a row of from five to seven round openings along its outer margin allowing a corresponding number of tapering gill-filaments to project from them. Continuing this row is a series of sealed-up openings that were utilized when the shell was younger and were closed as the animal grew. The inside of the shell is lined with beautifully marked mother-of-pearl of peacock green, including the large muscle scar wonderfully patterned in changing iridescent hues. If the rough exterior is ground or etched away, the shell becomes a marvelous object of polished changing sheen. It is utilized extensively for mother-of-pearl ornaments like those shown at the right. Many "abalone pearls," irregular in shape, are found within certain shells and make beautiful objects for which there is a ready sale.

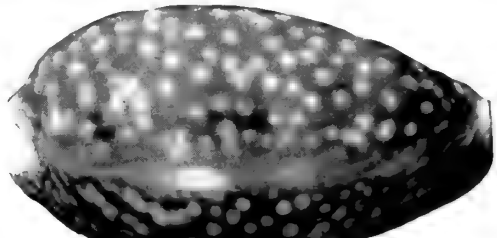
The flesh of the abalone is marketed extensively in China and Japan and is also popular in California for delicious soups, chowders, and "abalone steaks"



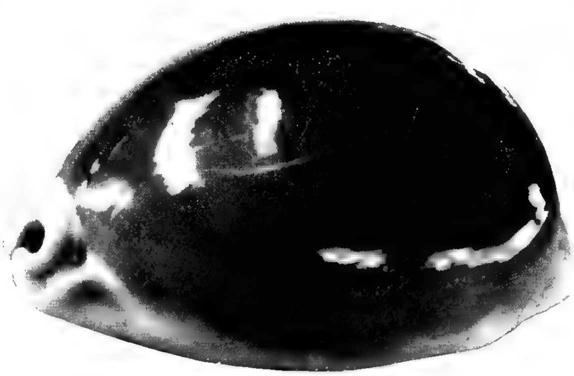
THE TURK'S CAP SHELL *(Turbo sarmaticus)*. This is a member of the group of Turban Shells to which the Green Snail *(Turbo marmoratus)*, shown on p. 13, also belongs. The species shown at the left is abundant at Cape Town, South Africa, where it forms an important article of commerce. The outside of the shell is brownish red and comparatively rough in the natural state, with a layer of black underneath, but this thin coat can be readily ground or rubbed off, leaving the entire shell of a beautiful pearly lustre with translucent greenish clouds. The shells are cut to adorn various articles such as knife handles, purses, cigarette cases, card cases, as well as various forms of jewelry



(Left and below) THE MEASLED COWRY *(Cypraea exanthema)*: The common cowry of the West Indies. Usually patterned with light round spots on a chestnut ground having bluish gray clouds. Some specimens are entirely without spots like the shell to the left. Often found crawling up mangrove stems in Southern Florida and Bahama swamps. Like other *Cypraeas*, the polish of the shell is due to the action of the reflected folds of the shell-forming mantle which covers it in life

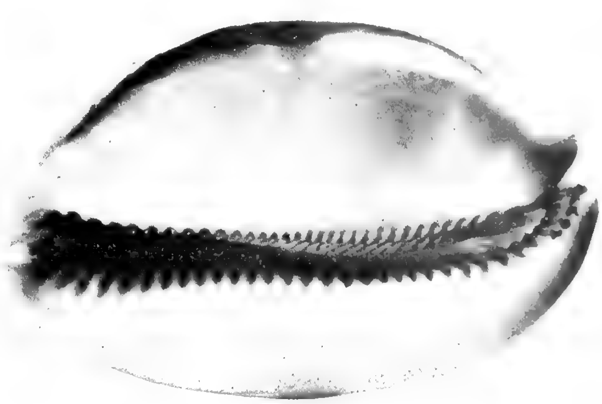


(Below) THE IMPERIAL HARP SHELL *(Harpa costata)*. The graceful shape of this beautiful shell suggests the name applied to it and its relatives. Naturally polished by the mantle of the animal, and variegated with rich coloring heightened by the bright orange of its lining, it is one of the most attractive of mollusks. This species is distinguished by close-set prominent ribs



TRITON'S TRUMPET (*Triton tritonis*) This shell sometimes grows to 18 inches in length. Its graceful form suggests a trumpet, for which purpose it has often been used by cutting a hole at the tip of its spire. It is remarkably colored with purple, brown, and reddish crescents on a light ground, each crescent just occupying a whorl width, and giving the effect of a gayly colored bird's plumage. At intervals along the spire may be seen the sharp edges of "varices," the former lips of the shell-opening when growth was arrested in successive stages of its life-history. The shell above was photographed in front of a mirror to show both sides

THE ORANGE COWRY (*Cypraea aurantium*). This brilliantly polished richly orange-colored cowry is prized by collectors both because of its rarity and beauty. It is found outside the reefs in deep water in such Pacific Islands as Fiji, the Solomons, and the Loyalty Group. Among the natives the wearing of these shells is considered one of the highest honors to be conferred by a chief, paralleling an Order of Merit among European nations

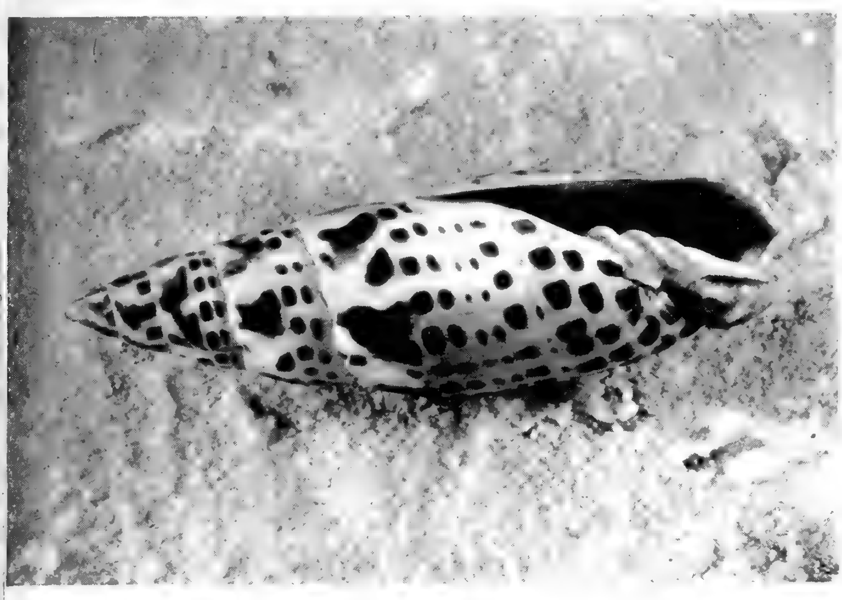


(Above) THE VENUS'S COMB SHELL *(Murex tenuispina)*. The Family Muricidae, to which this remarkable shell belongs, is a large one containing many species of highly organized, carnivorous mollusks spread throughout the world, especially in warm seas. Many of the species are characterized by grotesque or graceful spine formations. The slender lower shell-margin is extended forward to form a long "canal." Six varices, each with a row of delicate attenuated spines, give the name of the shell. To this same family belong several species of *Murex* or *Purpura* which produce a beautiful purple dye from the anal glands. It was *Murex brandaris* of the Mediterranean that furnished the Tyrian purple dye of the ancients and the royal purple of the Roman emperors

(Left) THE GREAT SCREW SHELL *(Turritella terebra)*. The gracefully turned spires shown at the left taper to a sharp point and sometimes attain a length of five inches. They are found in the Philippines and the Far Eastern Seas. It is said that such a shell suggested to Archimedes the principle of the screw

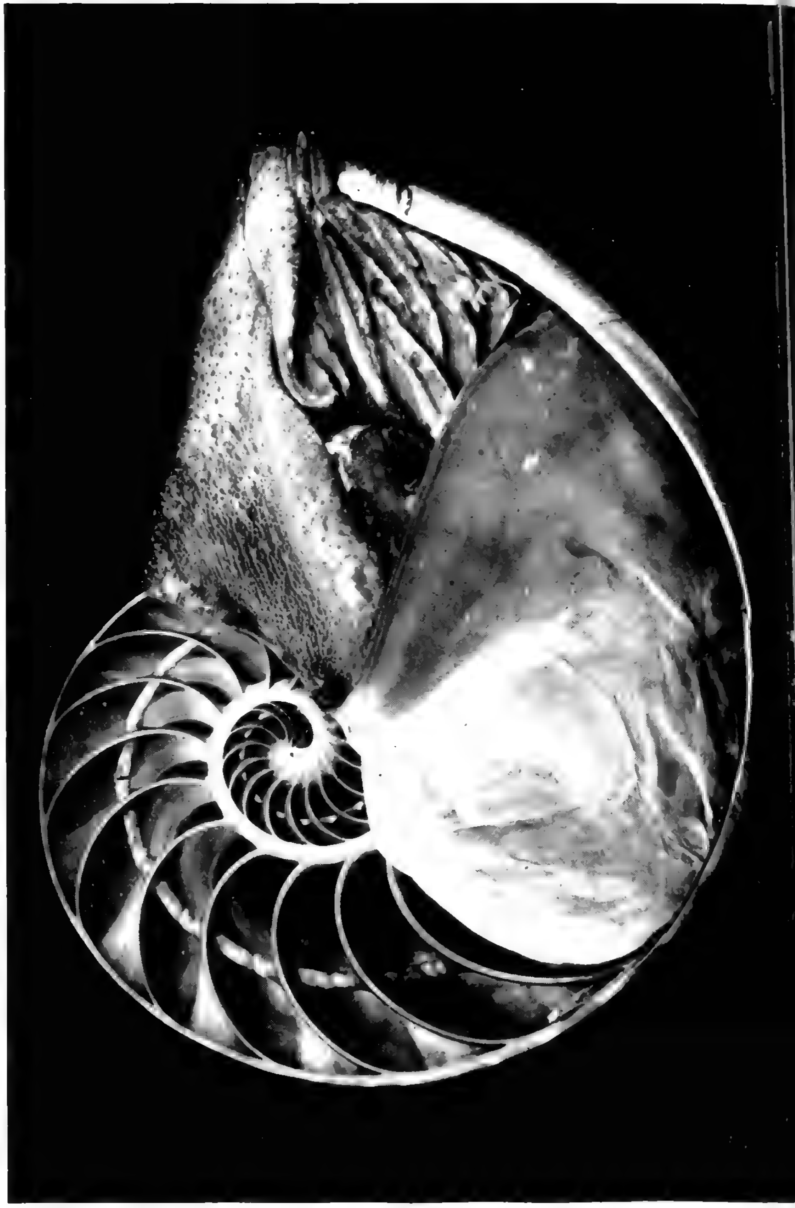
(Below) THE PAINTED THORNY OYSTER *(Spondylus pictorum)*. The genus containing these strange and beautifully tinted bivalves has been known since the time of the ancient Greeks, and they have always been favorites with shell collectors. They inhabit tropical seas. The species shown below comes from Lower California. Its spines are rose red and often orange or yellow

THE GREAT ARK SHELL *(Arca grandis)*. The heavy box-like valves of the ark shells give their name an appropriate significance. There is a strong bristling epidermis on the outside. The shells fit together closely, their thirty or more ribs interlocking. The hinge is very long and has a large number of teeth in comb-like series. The valves are strongly arched with curving beaks separated by triangular excavations spreading to the hinge. Viewed edgewise a lateral extension of this area has a heart-shaped outline. (Common from Cape Cod to the West Indies)



THE EPISCOPAL MITRE SHELL *(Mitra episcopalis)*. The Mitre Shells are widespread in tropic seas. There are more than 200 species, many of them brightly colored and much sought after by collectors. The Episcopal Mitre shown here has a white porcellanous shell. The closely compressed whorls form a graceful tapering spire with slightly convex outlines. It is conspicuously marked with bright orange spots nearly quadrangular in shape and neatly arranged in rows, except for those directly under the sutures of the whorls which are large irregular blotches. The shell-opening is streamlined with the general curvature of the spire, and several large "teeth" adorn the columella or central stem

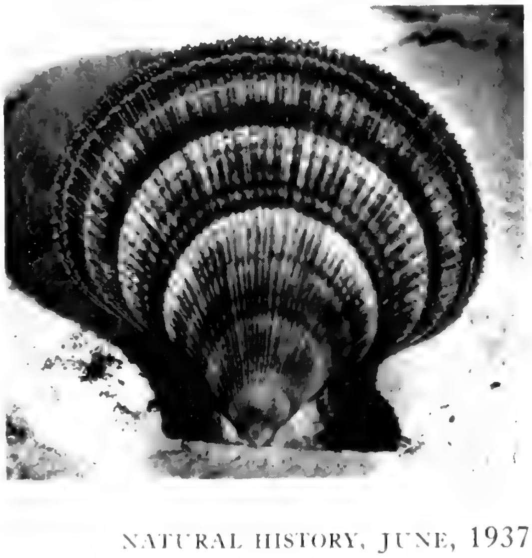
THE SPIDER SHELL *(Pterocera bryonia)*. This strange shell is related to our West Indian Queen Conch *(Strombus gigas)*, but is native to Tahiti. It is massive, often a foot in length. The outer surface is rough, but the lining is beautifully enameled with rose blending into orange. The long pointed projections from the edge of the shell-margin at first hollow but later becoming solid, grow out as the shell attains the adult condition and when it is moving over the sea-bottom it suggests the appearance of a huge spider



THE PEARLY OR CHAMBERED NAUTILUS *(Nautilus pompilius)*. This remarkable creature belongs to a bygone age. It is the only surviving species of a long line of fossil forms reaching back 500,000,000 years or more. It is a member of the Cephalopoda, the group which includes the squids and octopuses. The outer layer of shell is porcellanous, pure ivory in color. Otherwise the thickness of shell is mother-of-pearl of a most beautiful lustre, much used in manufacture of fancy articles. Within the hollow coil of the shell there is a succession of cup-shaped chambers diminishing in size until the smallest and earliest formed is reached at the center. The animal, with its many tentacles, lives in the outer chamber, as seen above at the right

(Left) The lower valve of this *Spondylus* or Thorny Oyster has become attached to the branches of a cluster of dead coral

(Right) NORTHERN SCALLOP *(Pecten islandicus)*, first discovered in Iceland, whence its name. Most brightly colored of the scallops, it is banded in red, orange, purple or pink



THE SPINDLE SHELL *(Fusus proboscidiferus)*. The Spindle Shells are found in warm seas and all are huge shells. The species shown is the giant of them all, at times reaching a length of two feet. The whorls of the spire are bordered with knobbed ridges. The shell tapers to a long open canal which is undulate and slightly bent to one side. Another open tube, the umbilicus, penetrates the spire and runs parallel to the canal above mentioned. The color is light brownish yellow and the outside is often covered more or less with a silky epidermal coat. This specimen came from Australia

BEFORE AND AFTER POLISHING: The Green Snail *(Turbo marmoratus)*. This is the largest of the Turban Shells. It is characterized by the horny outer layer of green, variegated with brown and whitish blotches. When this is ground off, a beautiful greenish pearly lustre is exposed, brightened by rainbow tints. Early Scandinavian kings used these shells for drinking horns. Examples have been preserved elaborately mounted in silver and adorned with jewels. The shoulders of the low spire are raised in a heavy ridge, and a row of large knobs stands out on the lower part of the body whorl, as shown to the left below. To the right is a fine specimen which has been ground to show the mother-of-pearl beneath. These shells are abundant in Eastern Seas, and the animal is used for food in Japan

(Continued from Page 3)
Many other forms are consumed locally by the natives of different countries where they are plentiful.

For other economic products than food the pearl-oyster is of outstanding importance, not only for the precious pearls occasionally produced, but also for the mother-of-pearl, which is used extensively for the manufacture of buttons, knife-handles, inlays, and all kinds of fancy ornaments. All nacreous shells of other species have varying value in this respect, the most important being the fresh-water clams, abalones, top-shells, and the turban-shells. Certain cowries have been used for money in the Far East and the Pacific Islands, while the American Indians used shells of the hard clam for making wampum. The tusk-shell also was utilized for this purpose by the Indians of the northwestern states. Shells have been used for various utensils, such as spoons, knives, dishes and basins. Tritons and conchs have been widely used as trumpets. The Purple Snails were crushed by the ancients and by many native Indian tribes for purple dye. Shells are ground up for road-making and are burned to obtain lime. Many of the beautiful species are used for ornaments such as necklaces, shield-decorations, earrings and the like. The great Orange Cowry is highly prized as a mark of rank of Fiji chieftains. The larger and more beautiful shells are doubtless used by many of our readers as household ornaments and curios and shell-collecting is progressively becoming of widespread general interest.

The mollusks are classified in five main groups, as follows:

The *Amphineura* or Chitons and their relatives. These are the most primitive of living mollusks, the larger number of them having an oval, creeping body with a jointed armor of eight transverse plates. They have a certain serial repetition of body-parts and breathe by means of a double row of plume-like gills.

The *Gastropoda* or snails. This is the most important group in number of species, distribution, and extent of diversification. They are the most ancient from the standpoint of fossil remains. The earliest shells resembled a "liberty cap," being cone-shaped with the shell uncoiled. Soon forms appeared with a one-sided roll; and a little later the spirally twisted, right-handed shell was established and has been generally characteristic, ever since. The twist of the shell is reflected in the internal anatomy. In some gastropods the shell has become reduced, and in others it has disappeared entirely.

The *Scaphopoda* or Tusk-Shells are relatively unimportant comprising only a few species. They possess a shell shaped like an elephant's tusk open at both ends.

The *Pelycypoda,* or bivalves, have the mantle divided into two halves each of which secretes a shell. They are hinged together and are nearly equal in size. The foot is flattened vertically and extends down from the enclosed body-mass. It may be protruded from between the two shells for digging or swimming. Delicate, flattened and fine-meshed gill-flaps on either side furnish breathing organs and an arrangement for filtering out food-particles.

The *Cephalopoda* include the swiftly moving squids, cuttlefishes, and octopuses. This highly organized and specialized group is composed of predaceous species with efficient eyes and method of propulsion of a peculiar kind. The Pearly Nautilus is the most ancient type. It is illustrated and described elsewhere in this article. The shell is well-developed in this species, but shows progressive degeneration in most of the squids where it becomes internal, and practically disappears in the octopuses. Thus the members of the group are freed from hampering armor to make possible a vigorously active life.

The American Museum of Natural History has an unusually extensive exhibition series of shells displayed in the Hall of Ocean Life. The accompanying photographs illustrate a few outstanding examples taken at random from the Museum shelves.

WHITNEY MEMORIAL HALL *of* PACIFIC BIRD LIFE

By Robert Cushman Murphy

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ROBERT CUSHMAN MURPHY, D.Sc.

Curator of Oceanic Birds

GUIDE LEAFLET SERIES

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WHITNEY WING

The new home of the American Museum's Department of Birds

By ROBERT CUSHMAN MURPHY

ON June 6, 1939, the Whitney Wing of the Museum, which extends northward along Central Park West from the Roosevelt Memorial Building, was formally opened in the presence of Mrs. Harry Payne Whitney and members of her family, the trustees of the Museum, the scientific staff, delegates from sister institutions and other invited guests. Addresses in celebration of the occasion were made by President F. Trubee Davison, by Mr. Cornelius Vanderbilt Whitney and Dr. Leonard C. Sanford, who are both trustees, and by Doctor Frank M. Chapman and the writer, of the staff, after which the visitors inspected the structure throughout its eight floors.

Whitney Wing is the result of a gift from the late Mr. Harry Payne Whitney which was equalled by an appropriation from the City of New York. The dedication of the building and the relation of the patrons to the Department of Birds are explained by an inscription on the second floor, which reads: "This wing of the Museum is the memorial of Harry Payne Whitney to his father, William C. Whitney. After the death of the donor, the collections of birds were greatly enlarged and the exhibits in the building completed in his memory by his wife and children."

Whitney Wing is the most commodious and best equipped ornithological headquarters in the world. It also houses the largest and most important collection of birds, numbering approximately 750,000 specimens. Coördination of the Museum's older material with the Rothschild Collection (likewise a gift from Mrs. Whitney and her children) and the birds obtained during the Whitney South Sea Expedition has produced an orderly systematic arrangement in new steel cabinets on seven floors of the building, so that every specimen of an ornithological nature is now readily available to investigators. In addition to offices and the "ranges" in which preserved material is safely stored, one floor of Whitney Wing is equipped with laboratories in which living birds may be bred and kept under observation in the course of studies relating to heredity and behavior.

Three floors are devoted in whole or in part to exhibition, these comprising an Art Gallery, a Hall of Biology of Birds and the Whitney Memorial Hall of Pacific Bird Life. The last, which is the present "show place" of the department, opens from the main entrance hall of the Museum in the Roosevelt Memorial and thus balances the Hall of Asiatic Mammals and the Akeley African Hall.

Whitney Memorial Hall is at present about half completed and its exhibits are the subject of the following eight pictorial pages. Its wall cases provide for eighteen habitat groups of Pacific birds, of which eight have thus far been installed and opened to the public. Ultimately these displays will cover the Pacific Ocean by means of selected localities extending from the Galápagos Islands and the coast of South America on the east to the Philippines, New Guinea and the Australian Barrier Reef on the west; and from islands near Hawaii, in the northern hemisphere, southward to one of the small outliers of New Zealand, on the verge of the Antarctic. Directions in the hall are similar to those on a map. The visitor, entering at the south end, finds himself abreast of a group illustrating bird life of the West Wind Zone, in high southerly latitudes, and then walks northward through the tropics into the northern hemisphere as far as the island of Laysan, at the edge of the North Temperate Zone, which is the latest of the eight exhibits thus far completed. The succession of bird life exhibited in the sky overhead follows the same plan, leading from Antarctic Snow Petrels and Whale-birds to equatorial Man-o'-War Birds and Tropic-Birds.

Mural charts in the entrance halls serve a purpose both of decoration and orientation; on them the visitor will find the exact location of each exhibit, as well as information about ocean depths, prevailing winds and currents and other geographic factors that have had much to do with the present distribution of life in the Pacific. One of the four maps shows also the division of this greatest of ocean basins into its natural geographical regions, both of the sea and of the archipelagoes, and the courses of a limited number of vessels notable in the history of Pacific science. These comprise the tracks of the pioneering ships 'Resolution' and 'Discovery' (1776-1780), commanded by James Cook; those of the Russian cruise of the 'Vostok' and 'Mirnyi' (1820-1821), under F. G. Bellingshausen; the famous voyages of the 'Beagle' (1832-1836) and 'Challenger' (1874, 1875); the surveys of the United States Fish Commission steamer 'Albatross' (1888-1910); and, finally, the lengthy wanderings of the American Museum schooner 'France' (1922-1932),

during the Whitney South Sea Expedition. The first mural, at the right of the entrance to the Hall, is an enlargement of a chart published by Abraham Ortelius, of Brabant, in 1589. It reveals the European conception of the Pacific Ocean three and a half centuries ago, and includes a basal shield in which the Museum acknowledges its debt to two generations of distinguished patrons, personified by William C. and Harry Payne Whitney.

The reproductions of photographs on succeeding pages offer only a fragmentary idea of the Hall, since many of them depict no more than small details of the several groups. The latter are, however, labeled in such a manner that Museum visitors can readily identify every element of the bird life and find a record of the part played by each of the many individuals who have coöperated in the creation of this notable exhibition.

(Below) ONE HALF OF THE EXHIBITS of bird life designed to reproduce in miniature the far-flung islands of the Pacific. The dome of the sky seems to rest upon the common oceanic horizon of backgrounds. Suspended beneath the clouds by invisible wires are sea birds chosen to match the respective life and latitudes of scenes in the cases, which represent localities in the Pacific between the Antarctic and the North Temperate Zone, including coral and volcanic, low and mountainous, islands, some of which are covered with teeming rain-forest vegetation while others are bare and arid. The memorial busts are portraits of Harry Payne Whitney (1872-1930), by Jo Davidson, and of his father, William C. Whitney (1841-1904), by Augustus St. Gaudens

AMNH Photo by Coles

SHIP-FOLLOWERS of the "Roaring Forties." Far south where strong westerly winds prevail over an ocean almost unbroken by continental land masses, vast numbers of petrels and albatrosses spend their whole life on the open sea except during the weeks of their breeding season. Such birds often follow sailing ships for food stirred up in the wake or tossed overboard, or because attracted by mere curiosity. Sooty and Wandering Albatrosses, Cape Pigeons, Whale-birds, Mother Carey's Chickens and other Petrels show in this scene, southeast of New Zealand in mid-summer (February). Beyond the bulwarks and rigging of the vessel on which the observer is supposed to stand, can be seen the Whitney Expedition schooner *France* running under shortened sail before the brave west winds. (Numerals adjacent to photographs refer to locations indicated on the maps)

AMNH Photo by Bierwert

1

2

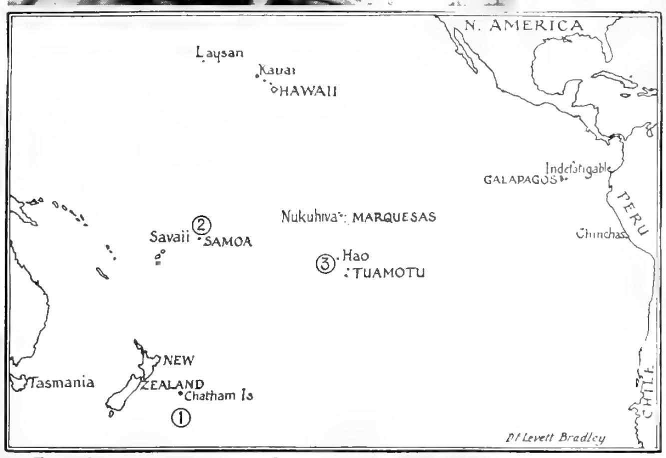
THE TOOTH-BILLED PIGEON: detail of the Samoan exhibit. This odd bird, which has been given the scientific name *Didunculus* because of a fancied resemblance to its big extinct relative, the Dodo, is the most striking and peculiar of all the birds of the Samoan archipelago. It lives on the two large islands of Savaii and Upolu, and nowhere else in the world. Although it is a member of the large, varied and widely distributed pigeon family, the Tooth-bill of Samoa has no very near relatives and is probably a relic of a branch of the pigeon group that has long since died out elsewhere. The Samoan exhibit as a whole shows a point on the slopes of Savaii where forest and grassland meet and where woodland birds consequently come into contact with those of the open

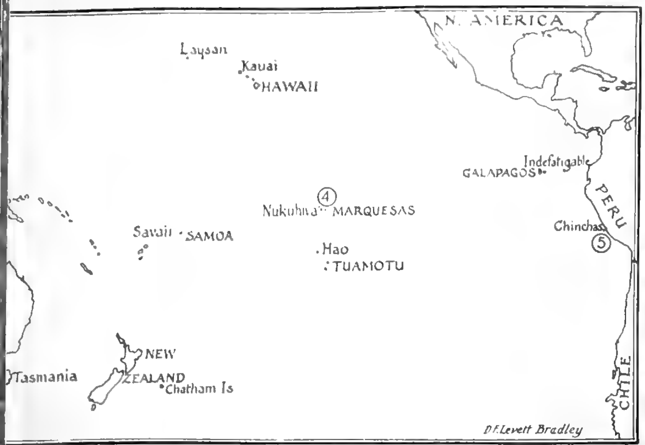
AMNH Photo by Bierwert

LIFE ON AN ATOLL in the Tuamotu archipelago: the island of Hao, showing the nesting ground of Man-o'-War Birds, Tropic-Birds, Boobies, seven species of Terns, the Reef Heron and the extremely rare Polynesian Sandpiper, of which a pair stands in the left foreground. The birds face the trade wind toward the pounding coral reef, with the lagoon of the islet showing at the left behind swaying coconut palms and pandanus

AMNH Photo by Coles

3





(Left) MARQUESAN FAIRY TERN: detail of the Nukuhiva exhibit. Most delicate of sea birds are the Fairy Terns, with their pure white plumage and huge dark eyes. This one has poised on filmy wings on the bough of a South Sea hibiscus. The exhibit as a whole shows a view over the valley of Taipi, scene of Herman Melville's "Typee" (1846), a romance of primitive life in the Marquesas Islands

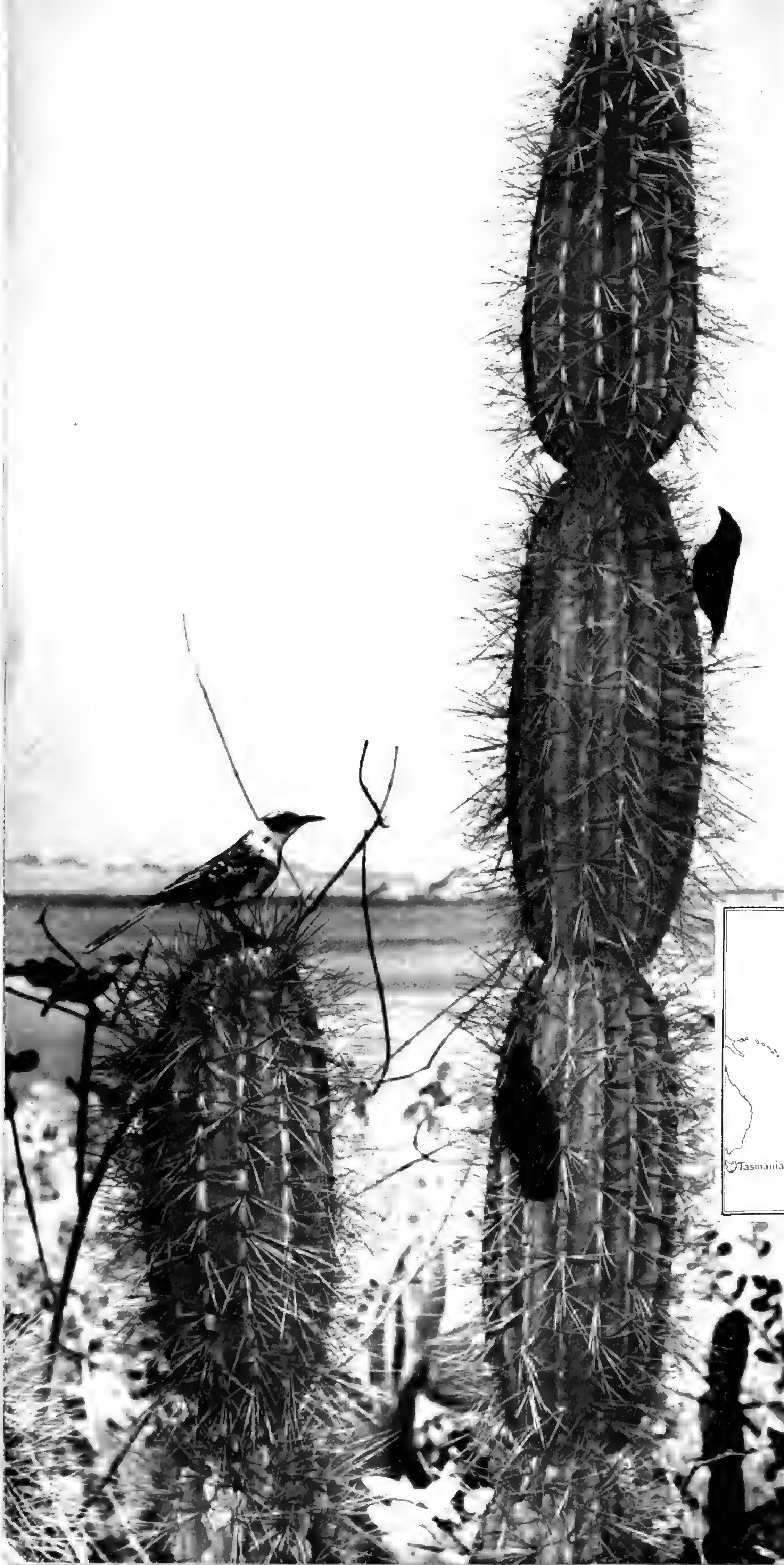
(Right) GUANAYS, or guano-producing Cormorants, of the coast of Peru: detail of the guano island exhibit. A fledgling *(at left)* is begging its parent for food. The Guanay has been judged upon a purely economic basis "the most valuable bird in the world"

AMNH Photos by Coles

PERUVIAN GUANO ISLAND EXHIBIT: a scene at the far-famed Chincha Islands, looking southward across the Bay of Pisco. Peruvian Cormorants, Boobies (on the cliff at the left), and Pelicans make up a distinguished trio of sea birds which produce annually in this rainless region more than a hundred thousand tons of marketable fertilizer worth 33 times its weight in farmyard manure. Guano exploitation in Peru constitutes the largest industry based upon the conservation of wild birds

5

6



Mockingbird and Cactus Finch: detail of the Galápagos exhibit. The view is from James Island toward Albermarle. The volcanic Galápagos Islands, which straddle the equator about 600 miles west of South America, have been isolated for long ages, and the origin of their peculiar plant and animal life poses many scientific problems. The Cactus Finch, climbing the prickles, is a member of a family of land birds (Geospizidae) found nowhere else. Nine species inhabit James Island alone. The curious specializations of the bills of these birds gave Charles Darwin, who visited the Galápagos during the cruise of the "Beagle" in 1834, his first ideas regarding "natural selection" as a mechanism to explain the process of evolution

AMNH Photo by Coles

6

Galápagos Hawks: detail of the exhibit. Fearlessness is a striking characteristic of the varied wild life of the Galápagos. It doubtless indicates an enormous period of time without molestation from man or four-footed enemies. Although dogs, hogs, goats, cattle and donkeys have been introduced and have reverted to a wild state, the native Galápagos animals retain a surprising tameness. These hawks illustrate two color phases of a resident species belonging to the cosmopolitan genus of our American Red-shouldered Hawk. They sometimes perch on the hats of visitors and readily step from their perches onto a proffered stick

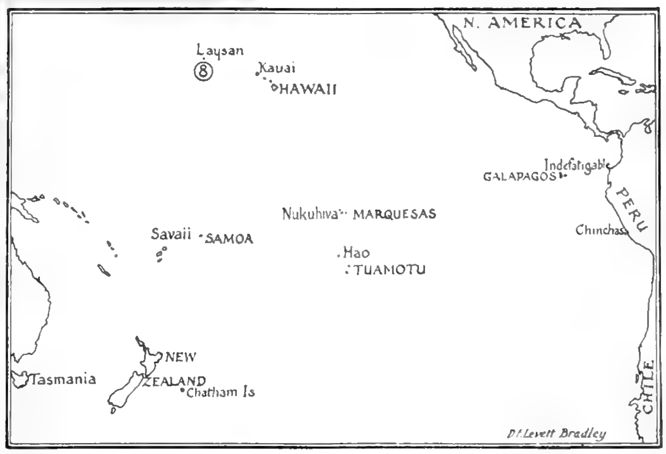
AMNH Photos by Coles

Scarlet Sickle-bill (Hawaiian Group): a bird important in the human history of Hawaii because from its red feathers the gorgeous ceremonial capes of the ancient island chiefs were made. The Sickle-bill is a member of the curious family of Hawaiian Honeycreepers (Drepanididae), confined entirely to this mid-Pacific archipelago. Although all closely related, the numerous species show remarkable variations in the bill, correlated with diverse feeding habits. This exhibit looks down a great canyon on the island of Kauai to the ocean four thousand feet below

7

Wandering Albatrosses: detail of the dome. This is the largest bird that flies, with a maximum wing-spread of eleven feet four inches. The huge sea fowl is one of the southernmost of its family, nesting on bleak islands close to the Antarctic and spending the greater part of its life on long travels over oceans well south of the equator

AMNH Photos by Coles



Laysan Albatrosses and Bristle-thighed Curlews: detail of the Laysan Island exhibit. Laysan is an islet in the long chain northwestward of Hawaii. It was created a reservation by executive order of President Theodore Roosevelt in 1909, since when the resident birds have been free of the human marauders from which they had previously suffered greatly. The Laysan Albatross is one of three North Pacific species of its family, two of which nest at Laysan in impressive numbers. These birds return each year to dance and mate, not in our spring season but in November, the springtime of the southern hemisphere, where most of their relatives live. The Bristle-thighed Curlew breeds in Arctic Alaska and makes Laysan a way station on its long migration toward islands in the South Pacific

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THE ORIGIN OF THE DOG

By Edwin H. Colbert

102

THE AMERICAN MUSEUM OF NATURAL HISTORY

THE ORIGIN OF THE DOG

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THE ORIGIN OF THE DOG
Wild Dogs and Tame — Past and Present

A panorama of the origin, genealogy and "social" background of the tractable wolf that emerged from the wilderness to become man's best friend

TO THE casual observer the numerous breeds of domestic dogs would seem to have reached the farthest possible limits of diversity among animals that may still be called by one name. And so they have, in one sense of the word. Compare, for a moment, the Great Dane with the Scotch terrier, the old English sheep dog with the Chihuahua, or the greyhound with the bulldog. Certainly there appears to be but little in common between these dogs, at least in their outer form, even though they are all dogs. One wonders what some future zoologist or paleontologist might do with the breeds of modern dogs, were he to find their bones among the ruins of what we are pleased to call our present-day civilization.

SIMILAR PSYCHOLOGY

Yet we know that the collie and the Yorkshire terrier and the Pomeranian are all dogs, because we have seen them originate and develop—so to speak—under the controlling influence of man's hand. Moreover, we know that they are all dogs because of their habits, for in spite of the dissimilarities in their appearances, they act much alike—they are all dogs by instinct and by reason of their peculiar psychology and the workings of their canine brains.

And when we get down to such a fundamental comparison as this we bump into the fact that the domestic dog, no matter what his looks may make him, is under the skin nothing more nor less than a tractable wolf—or, to look at it from another angle, the wolf is nothing more nor less than a wild dog.

The origin of the dog is lost in the mists of antiquity, for of all the animals domesticated by man, the dog was the first. Since the time when the question of the dog's origin was first seriously investigated, numerous attempts have been made to ferret out what his ancestors might have been, but despite diligent studies toward this end no definite conclusions have been reached. Indeed, zoologists differ among themselves, and at best they can for the most part only indulge in scientific speculations regarding the ultimate ancestry of the dog.

Generally speaking, most authorities agree that the dog is largely descended from the Eurasiatic wolf. Perhaps the story of the origin of the dog is a complex one, in that wild dogs have been severally and independently domesticated by man at different times in different parts of the world, while on top of this the dog after his domestication has perhaps often been crossed back with various wild dogs at different periods during the rise of human cultures. Certainly we know that the Eskimos, for instance, not infrequently cross their sledge dogs with wolves, to maintain the strength and endurance of the breed.

BACKGROUND OF DOG TRIBE

Which is to get back to a point made before, that the dog is nothing more than a tractable wolf —or tame wild dog, if you will. And to understand

THE ORIGIN OF THE DOG

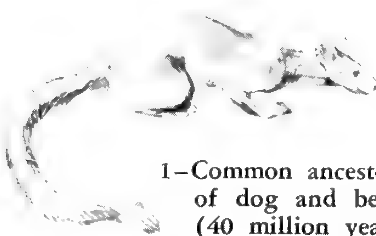
Compiled by Edwin H. Colbert *Drawings by* Margaret M. Colbert

7–The wolf, whose tractable descendants developed under man's guidance

4–African Hunting Dog (wild), *Lycaon*

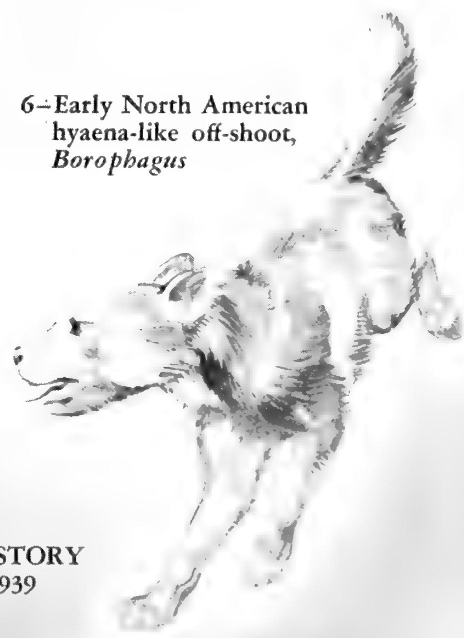
5–Immediate ancestor of dog family as we know it, *Tomarctus*

3–First "Bear-dog," *Daphaenus*



1–Common ancestor of dog and bear (40 million years ago), *Miacis*

2–Grandfather of all dog family, *Cynodictis*



6–Early North American hyaena-like off-shoot, *Borophagus*

THE prehistoric development of the wolf, from which the dog sprang, is typified chiefly by increase in running speed. The dog's ancestor *Cynodictis* (2) of some 20 or 30 million years ago was a slender, short-legged animal perhaps no larger than a mink. This animal began a line of evolution characterized by ever-increasing leg length and the development of an almost unique ability to run down prey mile after mile and seize it. This led to important "social" developments, involving group hunting. Competition, in turn, stimulated the growth of intelligence, along lines quite different, for instance, from that of the solitary cat. *Cynodictis* gave rise to two branches, one leading to the modern African Hunting Dog (4) and one through *Tomarctus* (5) to the wolves and domestic dogs. *Tomarctus* (of some 15 million years ago) differed but little physically from the wolves and wild dogs, but doubtless had far to go in intelligence. In modern times many widely different dogs have been bred, but the intelligence and adaptability of the dog remain distinctive.

NATURAL HISTORY
Magazine, 1939

this question of the domestication of the dog, it may be well, perhaps, to review the story of the origin and evolution of the dog and his cousins—to get a glimpse at the background of the dog tribe, the better to appreciate those characters that make dogs what they are.

The dogs, the wolves and their relatives belong to a family of carnivorous mammals known as the *Canidae*. This family includes, in addition to the dogs and wolves, the jackals, coyotes, dingos, the various dogs and foxes of South America, the Japanese "raccoon-dog," the numerous northern foxes and the fennec, and finally the African hunting dog, the East Indian wild dog, or dhole, and the South American bush dog. Even to the non-zoologist, these creatures are clearly recognizable as being related to each other, because of their general dog-like or wolf-like appearance. And in addition to these modern dogs there is a host of extinct canids, for the most part known only to the trained paleontologist—many of them of course very much like our modern dogs, but many more quite different from anything in the canid line surviving to the present day.

The canid or dog family (and here we use the word "dog" in an inclusive sense, to designate the numerous canids listed above) had its beginning some 40 million years ago, during the transition from the Eocene to the Oligocene period of geologic history. Those were the days when horses were no larger than small sheep, and had three toes on each foot, when rhinoceroses were still small horse-like running animals, quite hornless and probably completely lacking in the ferocity

MIACIS

that so distinguishes their modern descendants; when camels were dainty, gazelle-like creatures; and when the first ancestors of the great apes and man were small, tree-dwelling monkeys.

In those far-off days there lived a small carnivorous mammal known as *Miacis*, the offspring of some very primitive Eocene carnivores that had passed through the heyday of their evolutionary supremacy and were on their way to extinction.

Miacis was a small carnivore with a long body and relatively short legs—not so different in appearance from some of the modern East Indian or African civets, which are but the slightly changed descendants of this primitive ancestor. Perhaps *Miacis* spent a considerable part of his time in the trees, for it would seem probable that the earliest true carnivores dwelt in the primitive forests that sheltered so many ancestral mammalian types. This early carnivore, structurally

FIRST OF THE "BEAR-DOGS" ***(Daphaenus)***

and mentally in a low stage of development, seems to us to have taken but a slight step in the direction leading to its progressive heirs, yet in spite of its primitive form it had the potentialities that were destined to lead into a large and varied group of highly advanced mammals.

During the Oligocene period the first canids evolved in North America as the direct lineal descendants of *Miacis*. Of these there were two types, one a large, heavy, long-tailed dog known as *Daphaenus*, the other a much smaller, more slender animal, going by the name of *Cynodictis*.

Daphaenus was the first of the "bear-dogs," an animal as large as a coyote but longer-bodied, with relatively shorter legs, with a massive skull and an unbelievably long, heavy tail. These animals became progressively larger as time went on, until during late Miocene days (some 10 million years or so ago) they grew to truly gigantic proportions. Then some of them followed a line of evolution that involved a marked increase in weight, a secondary change from the typical run-

ning habits of the canids to a lumbering type of walk—due to the shortening of the feet—and profound modifications of the skull and teeth. Thus the bears arose, as descendants of the bear-dogs, in early Pliocene times.

GRANDFATHER OF ALL DOG FAMILY *(Cynodictis)*

As this first of the "bear-dogs" began to develop in the direction of the bears, the grandfather of all the dog family appeared. This animal, *Cynodictis,* retained the long body and short legs of the primitive carnivores. Indeed, like its ancestor, *Miacis,* it must have resembled to a considerable extent the modern Old World civets. And it was still so close to its earlier tree-climbing ancestors that it retained partially retractile claws, something like those of a cat.

This ancestor of the true canids gave rise to two distinct types of "grandchildren" in lower Miocene days.

One of these canids, *Temnocyon,* was ancestral to an evolutionary line that culminated in the modern hunting dogs of Africa and India. The African hunting dog, *Lycaon,* is a large, mongrel-looking canid with erect, rounded ears, and

AFRICAN HUNTING DOG *(Lycaon)*

marked by irregular brown and yellow spots. The East Indian hunting dog, or dhole, is very dog-like in its general appearance, with a long, pointed face, a bushy tail and a reddish coat. These canids, so like ordinary dogs to the casual observer, are in reality of quite an independent ancestry, and it would seem that the peculiar South American bush-dog, *Icticyon,* with an abbreviated face and a short tail, is, strangely enough, related to the Old World hunting dogs.

The other of these two lower Miocene canids, *Cynodesmus,* was the ancestor of a large and varied group of dogs, including our modern Eurasiatic and American dogs, wolves and foxes, which went through a major portion of their evolutionary development in North America.

Among the offspring of this ancestor of our common dogs *(Cynodesmus),* one branch, completely North American in its distribution and destined to become extinct, developed along a peculiar line whereby its members became very large, and strangely enough, hyaena-like. This does not mean, of course, that they are to be related to the hyaenas, but rather that they de-

"HYAENA-DOG" *(Borophagus)*

veloped by *parallelism* in a way similar to the hyaenas, because they lived the same kind of a life that the hyaenas live today. These dogs were the "hyaenas" of their time, occupying a rôle in North America that the hyaenas, which were just beginning to evolve along their strange line of evolutionary development, were learning to play in the Old World. These "hyaena-dogs," the most characteristic of which were *Hyaenognathus* and *Borophagus,* had heavy, bull-dog like skulls, with extraordinarily strong blunt teeth, adapted to crushing bones, rather than to slashing or tearing, for like the hyaena, these dogs were carrion feeders.

Finally, we may consider the true dogs as we know them, which evolved between upper Miocene and recent times as an offshoot from the *Cynodesmus* stem and had their immediate origin in a genus known as *Tomarctus.*

Tomarctus must have been very dog-like in its general appearance, and with but little change, except for the important one of the growth of intelligence, it grew into the wolves and wild dogs that spread throughout the northern world

FATHER OF DOG FAMILY *(Tomarctus)*

and surrounded primitive man in the East. From this ancestral form there evolved also, along a somewhat different line, the foxes, and the fennecs, small desert foxes of Africa.

Reducing these facts to their simplest terms, it may be said then that the canids, or "dogs" have followed four general lines or trends of evolutionary development. These were first, the gigantic bear-dogs, the direct ancestors of the bears, dogs in which size was at a premium and giantism was the final result of evolutionary progress. Secondly there were the hyaena-like or "hyaenognathid" dogs, which, though true canids through and through, imitated to some extent the hyaenas in their adaptations to life. Finally there were the two branches of dogs as we know them; on the one hand the hunting dogs of Africa and India, very much like the more familiar wolves

WOLF

and dogs but having a quite separate family history, and on the other hand the group of wolves, wild dogs and foxes, which may be considered as the central stem in this tree of canid history.

These were the particular specializations in the canid world. But throughout this melange of varying adaptations to different means of existence, there ran the central, unifying ties in the family history of the Canidae, like a strong warp weaving in and out among the varied threads of a patterned rug. These were: first, the universal adaptations among all of the canids toward a running mechanism of the body, capable of great speed; secondly, the attainment of a remarkably high degree of intelligence, commonly coupled with an extraordinarily well-developed sense of sociability; and lastly, the retention of a surprising amount of adaptability.

To continue our survey of the physical evolution among the dogs, the running habits so common to these animals must be stressed. The earliest dogs, such as *Cynodictis*, already showed some progress in this direction, although in these primitive forms the legs were relatively short as compared to the length of the body. But from the beginnings of canid history down to the point where man took a hand and produced specialized breeds, the story of evolution among these animals has been for the most part a tale of ever increasing limb length—a series of progressive adaptations for the running down and seizing of prey. In this respect the dogs differ from almost all of the other carnivorous mammals. The bears, their closest relatives, are huge lumbering creatures living for the most part on a diet of absurdly trifling items, and depending, when they do kill, on their great strength and size, while the raccoons, also close relatives, are primarily climbers. Of the other carnivores (except for the cheetah —an aberrant and quite uncat-like cat) only the hyaenas may be classified as primarily running animals. And the hyaenas do not rank at all with the canids when it comes to fast running—for they are not hunters but carrion feeders.

Thus we must think of the dogs—even the aberrant types that long since have become extinct—as the chasers of game, trailing their quarry mile after mile, hour after hour, until by the very diligence of their efforts and the cleverness of their methods they are able to overtake their prey. Of course, these remarks do not apply in their en-

tirety to all of the canids, but they outline the general rule for the adaptations in this family of carnivores.

"SOCIAL" INTELLIGENCE

The running adaptations in the canids have led to a method of life that has been very important in deciding the "social" life of these animals. For, early in the history of their development, these hunters must have discovered that it is much easier for a family to act together in running down a fleet victim than is such a feat for a single individual. Thus was born the habit of family hunting. And from this it was but a short step to the banding together of several families at advantageous times, to hunt as groups or packs.

Now this communal life, so characteristic of most of the dogs, led to the growth of sociability and a spirit of cooperation among the individual members of the group. Therefore, the dogs, instead of being individualists, such as the cats, became responsible members of a cooperative group, all working together toward a common end. Needless to say, animals living a life such as this are bound to exercise their intelligence to the utmost—they stimulate each other, and by working together they learn faster and build up the capabilities of their brains faster than would probably be the case if they were solitary.

Of course, generalizations such as these do not always hold. For among the canids, the foxes are strict individualists, and yet they are among the most gifted of the dog family, when it comes to a question of brains. Perhaps the answer is that the Miocene ancestors of the later canids were already extraordinarily intelligent animals, so that their descendants were bound to grow in wisdom, no matter what direction that growth followed. So it is that the foxes early in their history followed the solitary mode of life; but, living by their wits in much the same way that their wolf and wild-dog cousins lived, they naturally developed a sharp intellect. They became intelligent, as did all of the canids, because—among other things—of their heritage from precocious ancestors.

HUNTING BY RELAYS

It is interesting to notice a few of the means whereby this sociability is expressed. The tales of hunting by relays are so often told as to be almost trite. A number of wolves or wild dogs will map out a "course" over which the quarry is to be pursued. Then, several dogs will distribute themselves along this course—usually circular—and take their turns in chasing the antelope or deer, until the animal is fatigued to a point of exhaustion. In this manner it is relatively easy for several animals working together to accomplish their purpose with a minimum amount of effort on the part of the individual.

Indeed the spirit of cooperation is so highly developed within some of the canids that there are well authenticated records of wolves supplying food for an infirm and aged member of the pack.

One of the social habits of the wild dogs that is retained by their domestic relatives, is the rather annoying one (to us) of marking trees and posts with urine. I suppose that the average person gives but little thought to the origin of this habit, or its significance. Yet it is really quite a remarkable and characteristic adaptation among the Canidae, for it is a method whereby individuals are able to communicate with each other. The wolf has a series of bulletin boards scattered through his domain; these may be trees, rocks, bushes or other like objects. To these signposts he pays periodic visits, marking them to show other members of his group that he has been this way, and this is a part of his kingdom. And by sniffing at these posts he is able to determine what other wolves have been past in the last day or two, and whether or not they have had a right to be in his region. He learns whether the other visitors were male or female, young or old, well or ill, unworried or hunted. And through the use of these markers wolves seem to be able to spread the news of danger, so that when one animal is threatened, the entire community soon becomes aware of the threat. Thus an analysis of this habit shows that it is a highly developed trait among the canids, one in keeping with their sociability and their

(Continued on Page 14)

One Hundred Aristocrats of the Dog World

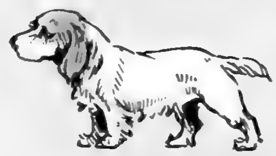
THE DOG was probably the first ar
domesticated by man, and the importan
his faithful help in the progress of the hu
race cannot be doubted. Much of his fa
history is lost in antiquity. It is known
archaeological evidence that man and
worked together as long ago as 5000 to
B.C. in northern Europe, in the period
tween the Old Stone Age and the New S
Age, and his history with man may be m

SETTERS

1—ENGLISH (*England*)

2—GORDON (*Scotland*)

3—IRISH (*Ireland*)



4—CLUMBER (*England*)

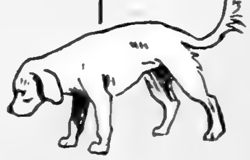
5—COCKER (*Engla*

11—"THE SETTING DOGGE"

As illustrated in 1621 in Gervase Markham's book, "Hunger Prevention, or the Whole Art of Fowling by Land and Water"

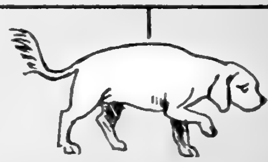
The setter, or "setting dogge" was used to set birds for the net. Netting went out of fashion about 1800

GROUP I SPORTING DOGS



13—LAND SPANIEL

Used for fowling on land



15—SPAYNELL

Gaston de Foix, who wrote in 1387, first mentions t
Spaniel, and credits it to Spain

About 1650 we find all dogs were divided in this manner:

(1) Dogs used to find deer or other animals for the chase (Finder or Pointing Hound)

(2) Dogs used to spring feathered game for the hawk (Spaniels)

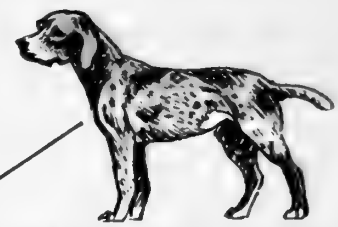
(3) Dogs used to set game for the net (Setters)

(4) Dogs used to retrieve wild fowl from the water (Water Spaniels)

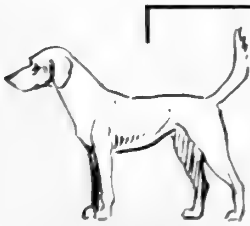
Their further development as gun dogs has been in keeping with the development of the gun

POINTERS

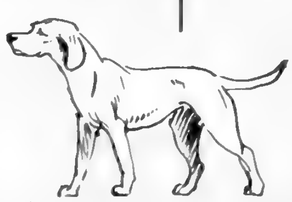
16—POINTER (*England*)



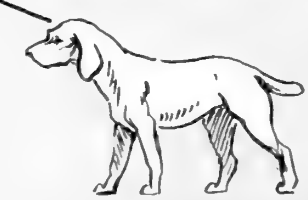
17—GERMAN SHORTHAIRED (*Germany*)



18—FOXHOUND

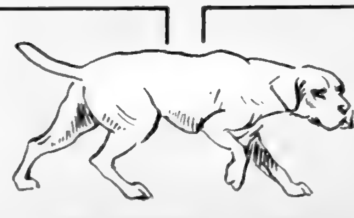


19—OLD ENGLISH POINTER

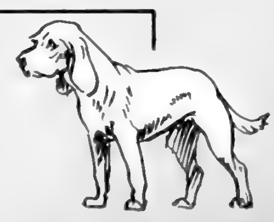


20—OLD GERMAN POINTER

21—POINTING HOUND, OR FINDER



22—SPANISH POINTER
as depicted by George Stubbs in 1802.



23—BLOODHOUND

older than that. But down to the time when "man's best friend" entered the pages of written history his story must be pieced together largely by implication. We can know little of the breeds of dogs that may have vanished from the earth since the days of our primitive forebears, for from their bones it is difficult to reconstruct the animal as he appeared in life and in many instances even to distinguish him from the wolf. Likewise these charts do not attempt to describe the various distinct types of dogs that are identified with certain native tribes of the modern world. Historical records are the basis of this presentation, which portrays 100 of the most familiar dogs of today and gives the foremost authentic facts of their origin. The six-fold classification into Sporting Dogs, Hounds, Working Dogs, Terriers, Toy Dogs, and Non-Sporting Dogs is the one conventionally accepted by the Kennel Club of America and by dog breeders, but it does not imply that dogs in one group are necessarily closely related to each other. It is adopted here for the sake of convenience and because no genealogical chart has yet been worked out on anatomical and genetic evidence.

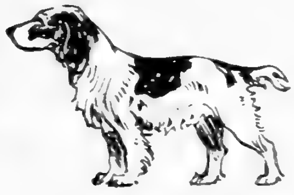
Compiled and drawn by

MORGAN STINEMETZ

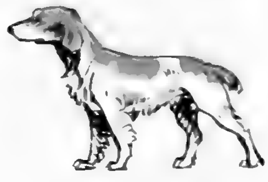
SPANIELS

6—FIELD (*England*)

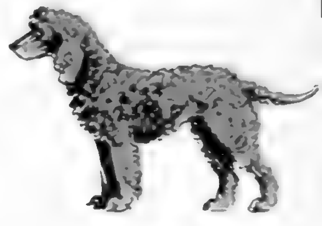
7—SUSSEX (*England*)



8—SPRINGER (*England*)



9—BRITTANY (*France*)



10—IRISH WATER (*Ireland*)

12—SPANIELL, OR "DOGGE FOR THE FALCON"

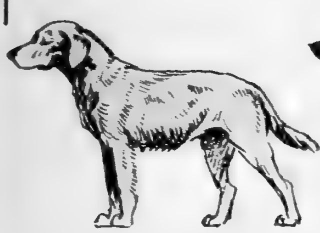
As pictured by Francis Barlow, 1626-1702. The Spaniell was used to flush pheasant, woodcock, etc., when hunting with falcons

Dr. Johannes Caius, the founder of Caius College, and court physician to Queen Elizabeth, wrote the first book devoted exclusively to dogs, in 1570. In this book, "Of English Dogges", he divides the Spaniels as follows: "Ther be two sortes, the first findeth game on the land. The other findeth game on the water." He divides the land Spaniels again as the kind that "serve the hawk," and "seconde, the net, or traine"

14—WATER SPANIELL, OR FINDER

As illustrated in Markham's book, "Hunger Prevention, etc.," 1621. The dog was clipped to make swimming easier

RETRIEVERS

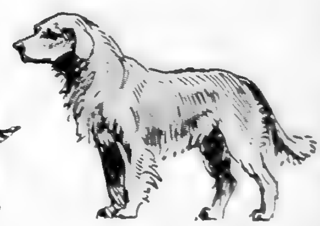


24—CHESAPEAKE BAY RETRIEVER

25—CURLY COATED RETRIEVER

26—FLAT COATED RETRIEVER

27—LABRADOR RETRIEVER



28—GOLDEN RETRIEVER

The Retrievers form a distinct group, and with the exception of the Golden, all trace back to dogs from Newfoundland. How the original dogs got to Newfoundland is not known, but it is presumed that they came as ships' dogs.

The generally accepted theory as to the origin of the Chesapeake Bay Retriever (24) is that he is descended from two dogs from Newfoundland rescued with the crew of an English brig wrecked off the Maryland coast. The American ship *Canton* made the rescue in 1807 and landed the English crew and the dogs on the shores of the Chesapeake Bay. The dogs were given to two gentlemen of that region in return for kindnesses to the crew. These two dogs, a male and a female, named "Sailor" and "Canton," made such great reputations as water-dogs and duck retrievers, that they were mated with nondescript dogs of the neighborhood which were used for the same work. Whether they were ever mated together, is not known.

The connection of the Curly Coated (25), Flat Coated (26), and Labrador Retrievers (27) to the Newfoundland is through a dog known as the St. Johns Newfoundland. These dogs were first brought to England in 1835 by vessels carrying salt cod from Newfoundland. Early writers often referred to them as Labradors. This has caused some confusion, as others claim that the original Labrador was a different dog altogether from the St. Johns Newfoundland, but brought to England about the same time from Newfoundland.

It is believed that the Curly Coated Retrievers were produced by crossing the St. Johns Newfoundland with descendants of the Old English Water Spaniel (a breed known to have existed in England as early as the 16th century) and the retrieving setter. At a later date, the Poodle was used as a cross to improve the curl of the coat.

The St. Johns Newfoundland and the original Labrador, (possibly variations of the same breed) are claimed as the foundation cross for the Flat Coated Retrievers. Added to this, at later dates, were both Gordon and Irish Setter crosses.

The modern Labrador Retriever is claimed to be the product of the cross between the St. Johns Newfoundland and the original Labrador. He is also claimed to be the original St. Johns Newfoundland. Although there is some doubt as to the real origin of these dogs, there can be little doubt that the dogs from Newfoundland helped materially in producing these natural water-dogs.

The Golden Retriever (28) springs from an entirely different line from the other retrievers. He is the descendant of an old breed known as the Russian Tracker. The Tracker first came to England in 1860 and was kept in its original state until 1870. In that year, one cross was made with the Bloodhound to reduce the size. The Tracker was a larger dog than his descendant, otherwise, they are practically the same.

Compiled and drawn by
MORGAN STINEMETZ

GROUP II

SCENT HOUNDS

29—BEAGLE
(England)

Origin of these hounds is lost in antiquity. The Beagle, smallest of trailing hounds, was known in England as early as 1560. Basically its stock is that of the Harrier and Foxhound

30—HARRIER
(England)

This name designated all hounds before pains were taken to breed them solely for fox hunting; assumption being that modern Harriers derive from Foxhounds. The first pack of Harriers formed in 1260 was maintained for 500 years

31—FOXHOUND
(England)

The first mention of Foxhounds was in 1735 in The Sportsman's Dictionary. By the beginning of the 19th century, type was well established and packs were numerous

32—BASSET HOUND
(France)

33—BLOODHOUND
(England)

Traditionally of French origin, the Basset really traces to the East. Descendants of the St. Hubert hounds (bred by St. Hubert Abbots since 6th century), they came originally from Constantinople. Kin to the Basset, the Bloodhound was developed in England through crossing St. Huberts with eastern hounds brought home by returning Crusaders. So sure is the Bloodhound's scent, he is the only dog whose evidence is accepted in court

GROUP III
WORKING DOGS

This general-purpose group is made up of dogs kept and bred for specific uses other than field sports. The accurate known history of most of these breeds does not extend much beyond the date of the first dog show, which was held in England in 1859. The early breeders of these dogs kept no records. They were interested primarily in the dogs' abilities, therefore mated only those dogs having the desired abilities in the highest degree. Eventually, in various localities, they became recognizable as distinct breeds with a highly developed sense for performing certain duties. Their refinement in conformation came at a later date with the beginning of dog shows

There are two distinct types of this small cattle dog. Both claim ancient ancestry. It is claimed that the Cardigan, with the crooked legs and long tail, was brought to Cardiganshire by the Celts in 1200 B.C.; while the Pembroke, with the straight legs and naturally short tail is said to have come with the Flemish weavers to Pembrokeshire in 1107 A.D. The Pembroke carries a trace of the Cardigan blood due to crosses made about the middle of the 19th century. The Cardigan in turn, carries a slight infusion of the blood of an old type of dog known as the Brindle Herder

39—WELSH CORGIS,
PEMBROKE *(Wales)*

40—WELSH CORGIS,
CARDIGAN *(Wales)*

SLED DOGS

46—ALASKAN MALAMUTE
(Alaska)

Alaskan Sledge Dog (now Malamute, from the Mahlemute Eskimo tribe) was found in Alaska by Russians long prior to U. S. purchase. Development of a pure strain dates only from 1926. This breed was used on two Byrd Expeditions

47—ESKIMO
(Alaska to Greenland)

The Eskimo dog probably originated in Eastern Siberia. They were taken by the Eskimos to Alaska, Northern Canada, Baffin Land, Labrador, and Greenland. They were used by Peary and Amundsen on Arctic and Antarctic expeditions

48—SIBERIAN HUSKIE
(Siberia)

The Siberian Huskie has been bred true to type in northeastern Siberia as long as earliest inhabitants can recall. He was first brought to Alaska (1904) as contestant in the 408-mile non-stop All-Alaska sweepstakes

49—SAMOYEDE
(Siberia)

Samoyedes have been bred for centuries by the Samoyed people. Introduced into England less than 100 years ago, they were used by both Shackleton and Scott on various expeditions

SHEEP DOGS

55—SHETLAND SHEEPDOG
(Shetland Islands)

Actual origin of the Shetland Sheepdog is obliterated by lack of records. Tradition declares them as old as Scotch Collies which came to the Shetland Islands, to become their probable sires

56—COLLIE
(Scotland)

The Collie, now beautified by breeding, has a cloudy origin, but his shepherd history is long. First shown in England in 1860, his U. S. popularity came later, though a few work collies were probably imported by colonials

57—BELGIAN SHEEPDOG
(Belgium)

Related to a number of Central European herders, the Belgian Sheepdog has two recognized varieties, the one shown (Groenendael) being the more important. The other (Malinois) differs in coat only. Both used in police work

58—GERMAN SHEPHERD
DOG *(Germany)*

The German Shepherd Dog is derived from old breeds of herding and farm dogs, and has been intensely developed in the last 45 years. It is widely used in police work

59—BRIARD
(France)

The Briard, an outstanding sheepdog, is recorded as far back as the 12th and accurately described in the 14th and 16th centuries. He belongs to a very ancient French strain

HOUNDS

SIGHT HOUNDS

34—AFGHAN HOUND
(*Asia*)

The modern history of the Afghan Hound dates from the World War, when dogs were brought back to England by returning British officers. Its history goes back to ancient Egypt. How it got to Afghanistan is not known

35—SALUKI
(*Asia*)

36—BORZOI
(*Russia*)

Carvings in Egyptian tombs support claims that the Saluki (Persian Gazelle Hound) is the oldest known domestic dog. First entering England (1840), they made little headway until imported from Arabia (1895). One of Borzoi's ancestors, the Saluki, came to Russia to slake a noble's thirst for fast dogs(mid 17th century). To get needed fur it was crossed with a collie-like native. Result: the Borzoi, well defined by 1750, in sketches of that period

37—GREYHOUND
(*England*)

38—WHIPPET
(*England*)

Though owing its modern development to England, the Greyhound can be traced back as far as we have any delineations of dogs. Always bred for speed, it was the first dog to be bred to shape, and the first rules for coursing with Greyhounds were drawn up at the request of Queen Elizabeth. The Whippet, "digest-sized" greyhound, was produced around 85 years ago by North England miners from greyhound and various terrier crossings, and later the small Italian Greyhound. He is called "the poor man's race horse"

41—IRISH WOLFHOUND
(*Ireland*)

The modern Irish Wolfhound dates only from 1862. That year, the ancient semi-legendary strain's few survivors were bred with Scotch deerhounds. Later, the Great Dane and Borzoi were admixed

42—SCOTTISH DEERHOUND
(*Scotland*)

Probably the longest preserved of the original hunters. Though stemming from Irish wolfhounds, the longevity of hounding deer, as against wolves, kept up the breed's general form despite the deer's speed requiring a lighter, racier dog

43—OTTER HOUND
(*England*)

The Otter Hound, first described in the early 14th century as a "rough sort of dog, between a hound and a terrier," did not make its appearance in the U. S. until the 20th century. First exhibited, 1907

44—NORWEGIAN ELKHOUND (*Norway*)

Known for extraordinary scenting abilities, the Norwegian Elkhound's ancestral claims trace back to the time of the Vikings, or earlier. Refinement of the breed began after 1877

45—DACHSHUNDE
(*Germany*)

Although recognized as essentially a dog of Germany, there can be no doubt that the Dachshunde was found throughout Western Europe at an early date. Official breeding data go back to 1840

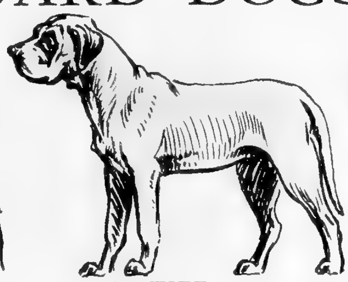
GUARD DOGS

50—DOBERMANN PINSCHER (*Germany*)

Developed in the last 45 years, the Dobermann traditionally stems from Black and Tan Terrier, Old German Pinscher and Smooth-coated Shepherd, Rottweiler, possibly others. Widely used in police work

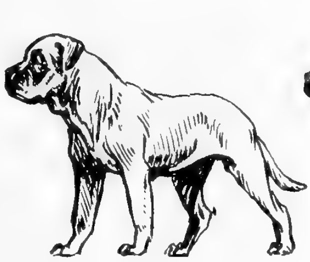
51—GREAT DANE
(*Germany*)

Natively German, the Great Dane has apparently no connection with Denmark. Strongest indication seems to point to the Mastin (big medieval European hunter) as his ancestor



52—MASTIFF
(*England*)

The term mastiff originally described a large group of dogs. The Mastiff of today belonged to this group, and it is claimed he was found in Britain by the Romans in 55 B.C.



53—BULL MASTIFF
(*England*)

About 80 years ago begins the Bull Mastiff's known history; gamekeepers then crossed the Bulldog and the Mastiff to secure a fearsome aid in their continual warfare with poachers

54—BOXER
(*Germany*)

The Boxer owes his perfection to Germany. He was developed within the last 100 years from dogs of this type known throughout Europe for centuries

MISCELLANEOUS

60—OLD ENGLISH SHEEPDOG (*England*)

There is no definite information about Old English Sheepdogs before the early 19th century. They were developed in the west counties of England as a "drover's dog." Many are born tailless

61—NEWFOUNDLAND
(*Newfoundland*)

The Newfoundland originated in Newfoundland from ancestors taken there as ships' dogs by European fishermen. The breed was developed in England during the last century

62—ST. BERNARD
(*Switzerland*)

Records of the St. Bernard date from 1707, at which time, however, it had already earned a reputation for rescue work. It was 1880 before the name St. Bernard was officially designated, though it had been in common use for some time

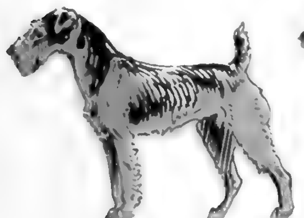
63—GIANT SCHNAUZER
(*Germany*)

First used as a drover's dog, the Giant Schnauzer came of crosses between the standard Schnauzer, herd dogs of South Germany, and later, the Great Dane. Practically unknown outside of Bavaria until 1910, it was introduced to the U. S. only about a dozen years ago

Originally, any dog small and game enough to hunt game and vermin in its burrow was called a terrier. From this common material the present terriers have developed. Though differing in type, they all have the same character—hard-biting, courageous dogs, small enough to go to earth. With two exceptions, they are distinctly a product of the British Isles

GROUP IV—TERRIERS

Compiled and drawn by
Morgan Stinemetz



64—WELSH TERRIER
(*Wales*)

Not Welsh, this terrier springs from the old English Wire-haired Black and Tan (oldest known English terrier) and was so called until 1887. It was first brought to the U. S. in 1888

65—MANCHESTER TERRIER
(*England*)

The original smooth-coated Black and Tan Terrier, described over 125 years ago, crossed with the Whippet, produced the modern Manchester. It was called the Black and Tan Terrier until 1923, when, because of its development and popularity in the Manchester district, it became, officially, "Manchester"

66—FOX TERRIER, SMOOTH (*England*)

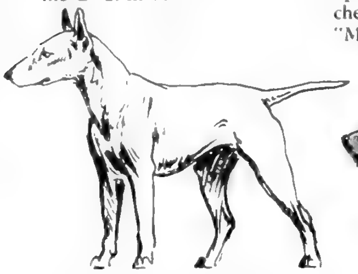
The progenitor of the breed seems to have been Col. Thornton's "Pitch," a dog well-authenticated in a picture painted by Gilpin in 1790, and thought to be the result of mating a small greyhound and an Old English Terrier

67—FOX TERRIER, WIRE (*England*)

The Wire (called Wire-haired Terrier until 1882) stems from the old English Broken-haired Black and Tan Terrier. Liberal crossing with smooth Fox Terrier brought the predominating white coat

68—AIREDALE TERRIER
(*England*)

The Yorkshiremen in the neighborhood of the river Aire developed this hunting terrier from a cross of the old English Broken-haired Terrier with the Otterhound



69—BULL TERRIER
(*England*)

As the name implies, this terrier is the result of a cross made about 100 years ago between the Bulldog and the Old English White Terrier (now extinct). The blood of the Spanish Pointer was added at a later date

70—NORWICH TERRIER
(*England*)

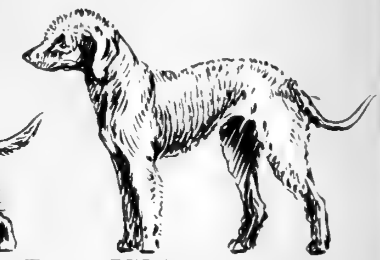
This dog is a newcomer to the U. S. but has been known in England since 1880. There is no definite information as to its origin

71—BORDER TERRIER (*England*)

The Cheviot Hills, which form the Border country, holds the secret of the origin of this little terrier. The breed has been carefully preserved by Border farmers for many generations

72—DANDIE DINMONT TERRIER (*England*)

Originating in the Cheviot Hills, this terrier was recorded as early as 1700. The name comes from Sir Walter Scott's "Dandie Dinmont," the farmer in *Guy Mannering*, who owned six of these terriers

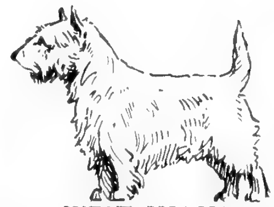


73—BEDLINGTON TERRIER
(*England*)

This terrier originated in the county of Northumberland well over 100 years ago. He possesses certain characteristics—the top-knot and the long drop ears—peculiar to only one other terrier, the Dandie Dinmont

74—CAIRN TERRIER
(*Scotland*)

The prototype of the modern Cairn was the old working terrier of the West Highlands and the Isle of Skye. The short legs are characteristic of all the terriers of Scotland



75—WEST HIGHLAND WHITE TERRIER (*Scotland*)

The breed originated at Poltallock, Scotland, well over 100 years ago. It is probable that it is of the same basic stock as the Cairns and the Scottish Terrier

76—SCOTTISH TERRIER
(*Scotland*)

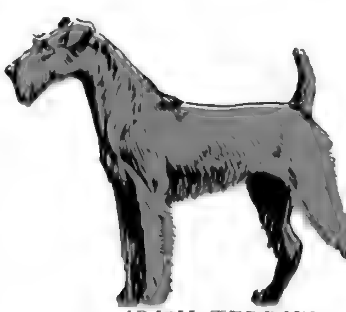
The first Scottish Terriers were exhibited in 1860. Though well established as a breed at that time, there is practically no definite information regarding them before that date

77—SKYE TERRIER
(*Scotland*)

An old breed from the Isle of Skye which was accurately described in 1570 in the first book devoted solely to dogs, "English Dogges," by Dr. Caius, court physician to Queen Elizabeth

78—SEALYHAM TERRIER
(*Wales*)

The Sealyham takes its name from an estate in Wales, where between the years 1850 and 1891 the breed was developed by Capt. John Edwards from dogs of obscure ancestry. First appearance in a dog show was in 1903

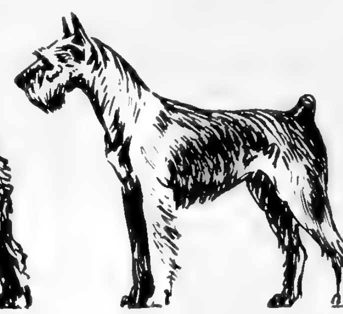


79—IRISH TERRIERS
(*Ireland*)

Irish Terriers were first exhibited in 1879. Aside from the fact that they came from the north of Ireland, their early history is only speculation

80—KERRY BLUE TERRIERS
(*Ireland*)

The national dog of the Irish Republic. Originating in the County Kerry, the Kerry Blue Terrier is claimed to have been pure bred for 100 years. They were first exhibited in the U. S. in 1922



81—SCHNAUZERS
(*Germany*)

This dog bears no relationship to the British Terriers. He is classed as a terrier in this country, but not so in Germany, where he originated, probably from crosses of the Poodle, with Wolf Grey Spitz and Old Pinscher stock

GROUP V—TOY DOGS

82—PEKINGESE (*China*)

He traces to the 8th century Tang Dynasty. First of these dogs to reach England were four taken from the looted Imperial Palace in Peking (1860)

83—JAPANESE SPANIEL (*Japan*)

Allegedly very old, its actual record dates from Commodore Perry's expedition (1852-54) and delivery of four of the dogs, the Emperor's gift, to President Pierce

84—ENGLISH TOY SPANIEL (*England*)

Descended from the "Spaniell Gentle, otherwise called the Comforter," according to Dr. Caius (1570). Credited with a Chinese origin

85—MALTESE (*Malta*)

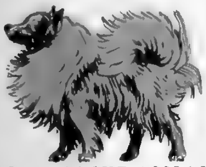
One of the oldest known breeds, Dr. Caius (1570) wrote of them: "That kind is very small indeed, and chiefly sought after for the pleasure and amusement of women"

86—YORKSHIRE TERRIERS (*England*)

Developed in Yorkshire and Lancastershire, there is no information on origin of this breed. First showing: England (1861) as "Scotch Terrier." Introduced here about 1880

87—TOY POODLES

Today's breed springs from the larger Poodles. That the popular 18th century "White Cuban" came from Cuba is doubtful. But his true "birthplace" is an enigma



88—POMERANIANS (*Germany*)

Developed in Pomerania, from old Spitz stock at an unknown date, the breed was not well-known in England until 1870. It was first exhibited in the U. S. in 1892

89—PAPILLON (*Spain*)

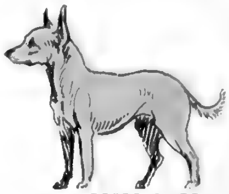
Developed from the "dwarf spaniel" (dating from 16th century), these little dogs, favorites of Mme. de Pompadour and Marie Antoinette, were painted by Watteau, Fragonard, and Boucher

90—GRIFFON (*Belgium*)

Descended from the small Belgian street dog and the Affenpinscher, it was unknown until 1895 outside Belgium. Some say both Pug and English Toy Spaniel influenced this development

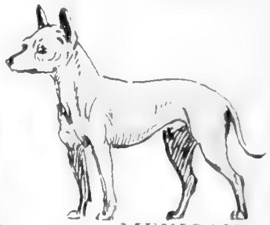
91—PUG (*China*)

Its pópularity there plus its introduction to England by the Dutch East India Company, have often given Holland credit for the origin of the Pug. China seems more likely



92—CHIHUAHUA (*Mexico*)

The known history of the Chihuahua begins about 1850, when specimens of the breed were found in the state of Chihuahua. Believed to be a descendant of the Techichi, a dog of the Toltecs



93—MEXICAN HAIRLESS (*Mexico*)

Contrary to general belief, Mexico is not alone in having a native hairless breed. The Mexican Hairless strongly resembles a Chinese hairless breed

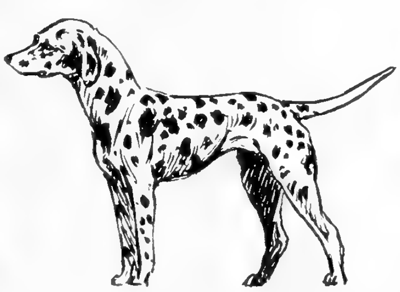
GROUP VI—NON-SPORTING DOGS

94—POODLE

Though popularly regarded as a dog of France, the Poodle is believed to be of German origin. The clipped Water Dogge shown in the first group (14) bears a striking resemblance to the Poodle and is thought to be one of his ancestors. Where the custom of clipping poodles originated is not known

95—CHOW CHOW (*China*)

The marked peculiarity of having a blue-black tongue distinguishes this ancient Chinese breed from all other dogs. First English description given in the Rev. Gilbert White's *Natural History of Selborne,* tells of a pair brought from Canton by a neighbor in 1780. Finally popular in England by 1880, it was first exhibited ten years later in the U. S.



96—DALMATIAN (*Dalmatia*)

There is very little information as to the Dalmatian's lineage, but he is believed to have descended from the same class of hound as the pointer. Old pictures and engravings depict the Dalmatian very nearly as he is today

97—BULLDOG (*England*)

The Bulldog is entirely British in his origin and development. By careful selection, the modern dog has been developed from the dog used for the once popular sport of bull-baiting. As we know him today, the Bulldog bears little resemblance to his ancestor, and has none of his viciousness

98—BOSTON TERRIER (*United States*)

The Boston Terrier is an American product, named after the city of its origin. The crossing of a Bulldog and a white English Terrier about 60 years ago is claimed to have started this breed. Inbreeding and careful selection have made him what he is today

99—FRENCH BULLDOG (*France*)

Several varieties of the small, or toy Bulldog bred in England around 1860, were exported liberally to France. It is generally conceded that these dogs, crossed with other breeds, evolved the French Bulldog. There is little accurate information

100—SCHIPPERKE (*Belgium*)

Although known to have originated in Belgium's Flemish provinces, little accurate knowledge and considerable difference of opinion have characterized investigations of this breed. Prior to 1888, they were called Spits or Spitske. This country first saw them in 1885

(Continued from Page 7)
gregariousness, and one that is of the utmost importance in the scheme of their lives.

Examples might be multiplied *ad infinitum*, but perhaps these are enough to demonstrate the rare combination of mental acuteness and co-operation typical of the wild dogs.

It is very difficult, and more than a little bit risky, to dogmatize as to the ranking in intelligence among the mammals, but certainly it is safe to say that the canids are among the most intelligent of the warm-blooded animals. In a large part this intelligence is innate, just as it is among all of the carnivorous mammals. But it is quite definitely augmented by the sociability of the dogs and their relatives, thereby making a combination of qualities that particularly suit these animals to live commensally with another intelligent species—Man.

Then, there is the remarkable adaptability of the canids, a trait that has been of immeasurable worth in enabling them to become suited to their surroundings. Structurally the canids are not highly specialized. Except for their long legs and compact feet as adaptations to running, and their highly developed brains, they are on the whole rather generalized carnivores. Hence they are unusually plastic, both physically and psychically, and are able to adapt themselves readily to changing conditions.

Contrast, if you will, the numerous types of wild canids with the cats. Cats, whether they be small or large, are generally speaking of one pattern, for these animals became highly specialized early in their phylogenetic history, and have been rigidly fixed ever since. Consequently a tiger and a puma and a house cat are much the same, except as to color and size, whereas the canids in their wild state show a rather wide range of adaptive radiation. This plasticity among the canids is illustrated artificially but none the less effectively by the extraordinarily numerous breeds of the domestic dogs, showing a range in size between the Chihuahua and the Great Dane and a range in form between the bulldog and the greyhound. What a contrast these artificial adaptations among the domestic dogs afford, as compared with fixity of the domestic cats.

But this plasticity in the canids is not confined to physical make-up alone, for these animals—at least the gregarious canids—are remarkably adaptable in their mentality. It is this fact that has made the dogs so amenable to domestication; the dog has been domesticated because he has been willing to conform to the ways of man, not only in his habits but even in his manner of thinking.

To thoroughly appreciate and really understand the domestic dog, it is necessary to become acquainted with his heritage from numerous ancestors, running back in an unbroken line for many millions of years, and to keep in mind the many ties that bind him to his wild relatives of the present day. When we take this comprehensive view of the dogs as we know them, we get an inkling of the various factors of heredity, environment and behavior that have worked together to bring about that combination of characters and traits which we recognize as being typical of the Canidae. Thus we see that the dogs are members of a varied and a highly interesting family of carnivorous mammals—a family of swift runners, characterized by the attainment of a high degree of intelligence, by a general feeling of sociability, and by a trait of adaptability that has enabled them to adjust themselves to a rapidly changing environment. Is it any wonder, then, that they should be the first animals to fall under the all-prevailing influence of Man?

THE HISTORY OF THE VALLEY OF MEXICO

AN ILLUSTRATED CHART

A SUPPLEMENT TO SCIENCE GUIDE NO. 88
ARTISTS AND CRAFTSMEN OF ANCIENT CENTRAL AMERICA

By GEORGE C. VAILLANT

Science Guide No. 103

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The History of the Valley of Mexico
PANEL II
Toltec Civilization
PANEL III
The Chichimec Period
PANEL IV
Aztec Period
Figurines of the Chichimec Period were crude but variegated.

MAN AND NATURE
PUBLICATIONS

PEARL DIVERS

By Roy Waldo Miner

The American Museum of Natural History

THE PEARL DIVERS GROUP

This group represents a scene on the sea floor of the enclosed lagoon of the coral atoll of Tongareva, a little ring-shaped island eleven miles in diameter situated in the South Pacific Ocean about 2000 miles due south of Honolulu. Through the large central opening, two Tongarevan pearl divers are seen plunging down into a coral gorge in the heart of one of the magnificent submarine formations of this beautiful island. They are engaged in gathering precious pearl clusters from the ocean bed in spite of the gruesome octopus at the entrance of a nearby cave, the poisonous sixteen-pointed sea star armed with hundreds of sharp red spines, and the shark lurking in the watery distance.

Through the window at the left, a bed of furbelowed *Tridacna* clams is seen half buried in the rocky slope which rises to the cliff-like coral wall of the gorge, their sinuous openings gaily festooned with brightly colored mantle edges.

At the right of the group, the visitor may look into the cave of the octopuses, one of which slides threateningly down from a rocky shelf above. Another lurks in a shadowy crevice, while a third octopus, swimming out through an arched tunnel into the distant watery vista, trails its tentacular arms behind.

This group emphasizes the delicate beauty of the fairy-like corals of the South Seas, among which the Polynesian divers spy out the precious pearl shell, as contrasted with the strange and weird giant branching species of the great Bahaman Coral Reef Group, also at this end of the Hall of Ocean Life.

The Pearl Divers group, as now completed, is the gift of the late Edith Haggin De Long, whose generosity has made possible not only the elaborate modeling and assembling of the group itself, but also the mural on the gallery floor immediately above. This fine painting by Francis L. Jaques depicts the pearl divers plunging from their outrigger canoes to secure the precious shell as shown in the main group below.

The expeditionary work for this group was undertaken during the Fall of 1936 through the generosity and cooperation of Templeton Crocker of San Francisco who accompanied the expedition and placed at the Museum's disposal the facilities of his graceful schooner yacht, the ZACA. Contributions for this trip were also made by Junius S. Morgan, George T. Bowdoin, Clarence L. Hay, and Wyllys Rosseter Betts, Jr. The Museum personnel consisted of Curator Roy Waldo Miner, leader, Wyllys Rosseter Betts, Jr. as field associate, and Chris E. Olsen, departmental artist and modeler. An account of this expedition is given in the accompanying text.

The group itself was conceived, designed, and directed by Dr. Miner. The submarine background is by Chris E. Olsen, who was also the chief modeler of the exhibit. In this, he was ably assisted by Bruce K. Brunner. The excellent work of these two artists characterizes the major part of the display. The fishes represented were carefully cast and beautifully colored by Dr. George H. Childs, the scientific artist of the department, from molds made in the field by members of the expedition. The original field sketches for these fishes were painted by Toshio Asaeda, the expeditionary artist. Dr. Childs was also responsible for the accurate models of the octopuses. Ten tons of actual coral specimens are featured in the exhibit. The repair, preparation, and basic coloring of this remarkable series is largely the work of Worthington H. Southwick. The two life-size figures of the Tongarevan pearl divers were sculptured by John W. Hope.

June 10th, 1941

PEARL DIVERS

By

ROY WALDO MINER

Curator of Living Invertebrates

GUIDE LEAFLET SERIES

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AMNH [illegible] Coles

THIS *Tridacna* CLAM, adorned with a fragile living coral, grew on the lagoon floor, 25 feet below the surface. The photograph represents the animal modeled in wax within the actual shells so as to display its gorgeously colored mantle edges, which, in life, expand over the scalloped shell margins

PEARL DIVERS

By Roy Waldo Miner

Curator of Living Invertebrates, The American Museum of Natural History

An account of an American Museum expedition to the South Pacific to obtain material and data for a new group in the Hall of Ocean Life depicting the undersea activities of the Polynesian natives in their traditional search for the treasures of the deep

THE *Zaca* was lying at anchor off Penrhyn Island, called Tongareva by its native inhabitants. A stiff breeze, blowing over the land from the east, raised dancing multitudes of white-caps, their snowy crests contrasting strongly with the deep ultramarine of the tropic sea. The white strand of the distant shore, disappearing and appearing alternately as the foaming breakers dashed against it, was crowned with long lines of coconut palms tossing their green plumage as the trade wind swept over them. Midway, their verdant line was broken by two shelving points, bare and rock-strewn, that seemed nearly to meet on either side of the narrow West Pass, the only practicable entrance for our vessel to the sheltered lagoon of the coral atoll.

As we watched, a sail appeared in the opening, delicately threading the tortuous channel, and headed for the open sea. It was followed by another and another, and finally a multitude of craft, obviously smaller than the leading vessel, emerged from the opening and shaped their course directly toward us before the wind.

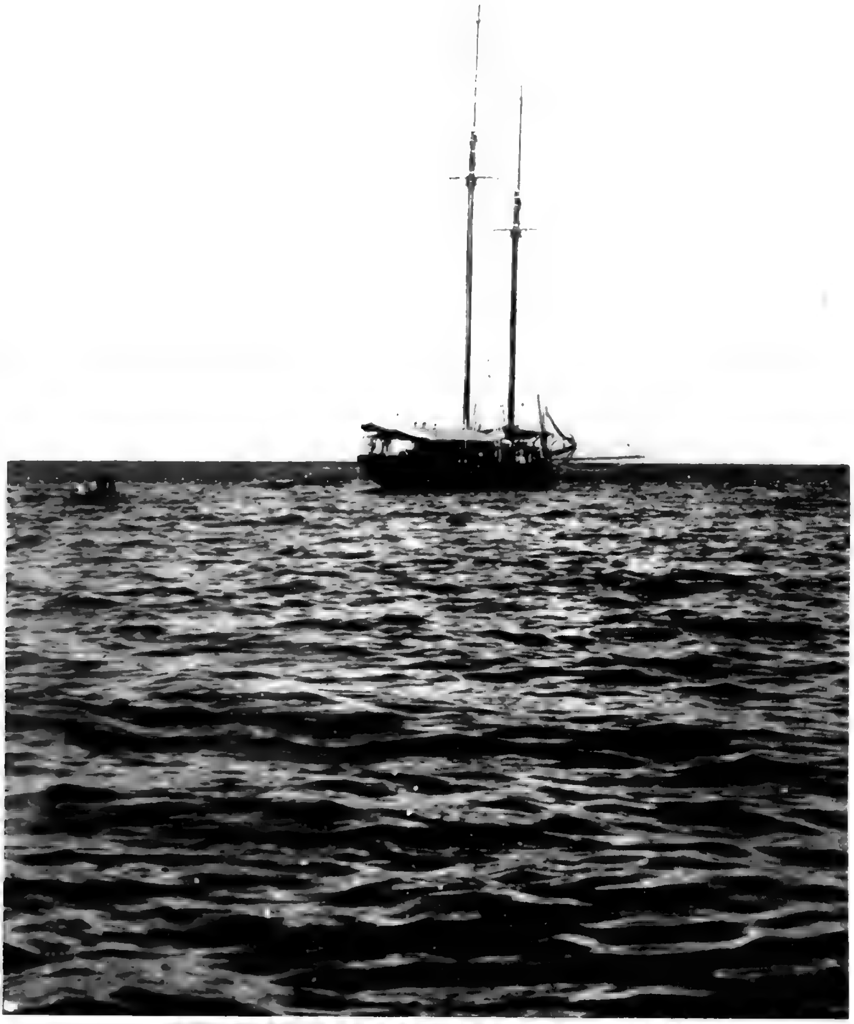
Examining them through our glasses, we saw that the larger boat was a sloop, flying the blue of the British colonial ensign, and realized that we were to receive an official call from the Government Agent in charge of the island. As the fleet drew nearer, we made out that the smaller vessels were numerous outrigger canoes, their single sails manipulated skillfully by their Polynesian navigators. Soon they arrived alongside, and, as the Agent, Philip Woonton, came aboard, the owner of the *Zaca* and sponsor of our expedition, Mr. Templeton Crocker, met him at the gangway and escorted him aft to meet us. Almost immediately, the dusky-skinned natives swarmed over the gunwales, examining the vessel and fraternizing with the sailors forward.

Philip Woonton, clad simply in jersey and white trousers, with a native broad-brimmed straw hat shading his swarthy face, greeted us hospitably. Mr.

FRANK TIAGA, Samoan sailor from the *Zaca,* equipped with water-tight goggles, diving for corals. Through his efforts many of our finest specimens were secured, including the great 900-pound coral shown on page 261

Photo by Wyllys R. Betts

(*Left*) THE GRACEFUL POWER-SCHOONER, *Zaca,* which carried our expedition to the South Seas, riding at anchor outside the atoll of Tongareva, while waiting for a native pilot

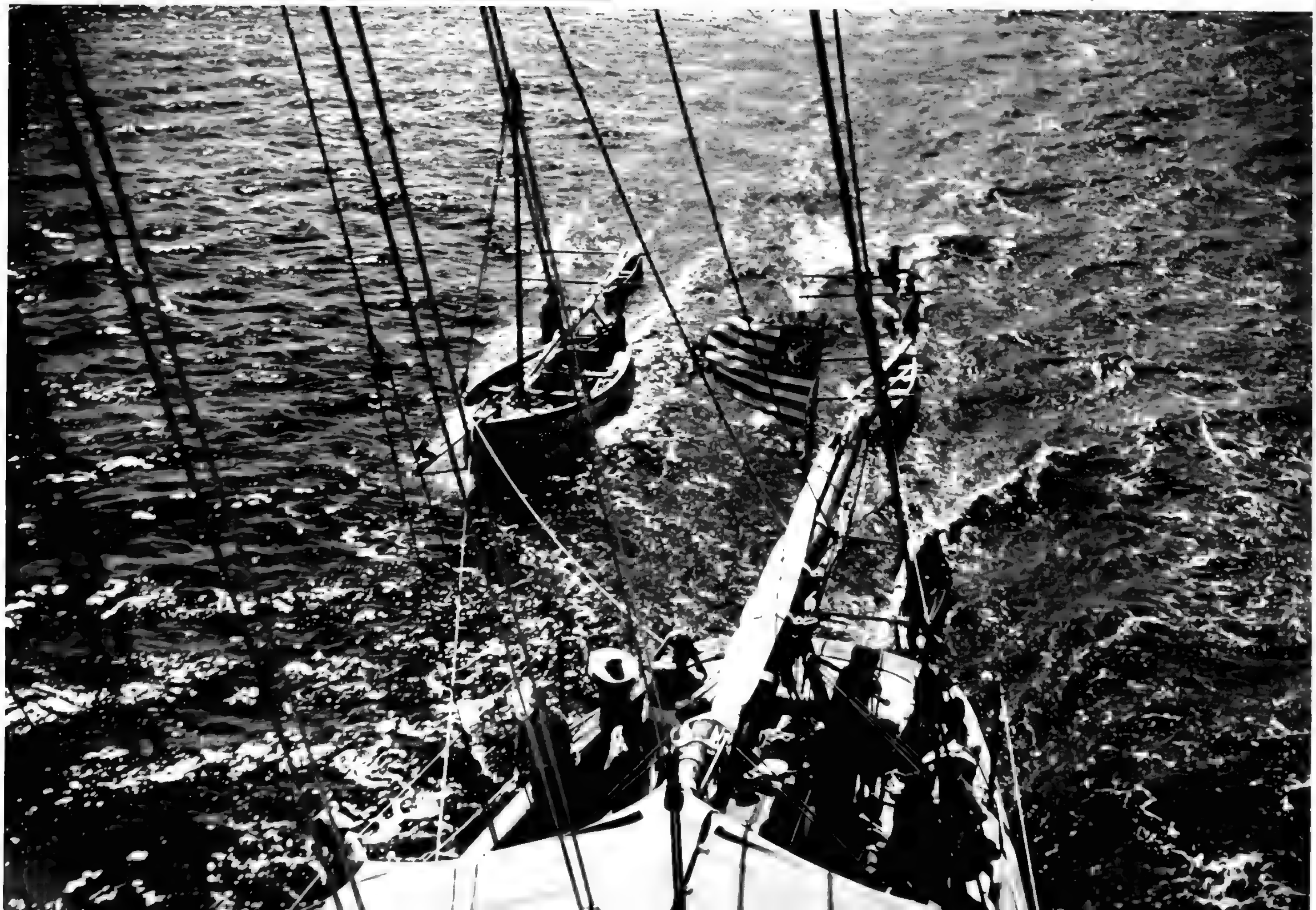


(*Right*) THE *Spray,* official boat of the British Government Agent, Philip Woonton, emerges from the Tongareva lagoon to welcome the expedition to the island

Photos by Roy Waldo Miner

(*Below*) THE *Zaca* under way toward the West Pass, the difficult lagoon entrance, guided by a skillful native pilot. Mr. Crocker, Mr. Woonton (in broad-brimmed hat), and other members of the Museum party are standing near the after rail

Photo by Toshio Asaeda



(Left) NATIVE OUTRIGGER CANOES being towed astern as seen from the masthead. Their native crews are aboard the *Zaca* curiously examining the vessel and fraternizing with the sailors forward

(Below) THE NATIVE VILLAGE of Omoka nestles beneath groves of coconut trees on a point of land inside the circle of the lagoon. The *Zaca* came to anchor beyond this point

[illegible]

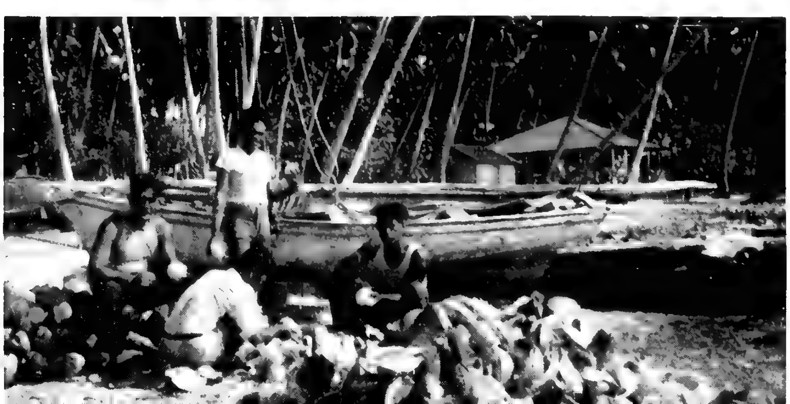
(Left) THE NARROW NATIVE CANOES are made from scooped-out tree trunks with plank gunwales fastened on by twisted cords of coconut fiber. Outriggers keep them from capsizing when under sail

Photos by Roy Waldo Miner

(Below) NATIVE BOYS, supported by half submerged branches of trees, swam around the *Zaca* for hours, curiously watching our movements

(Below) TONGAREVANS cleaving coconuts on sharpened stakes. The coconut meat is dried to make copra and sold to passing trading schooners. It is eventually used for making confectionery and soap

(Below) THE DENSE GROVES OF COCONUTS furnish the natives with all the necessities of life, including food, drink, clothes, and housing



Crocker handed him our credentials, including a letter of introduction from our friend, Dr. Peter Buck, the Director of the Bishop Museum of Honolulu, who had previously spent much time on the island studying its inhabitants, and had established most cordial friendship with him. This settled the matter and we were informed that the entire island and its inhabitants were at our disposal.

When Mr. Woonton learned that the purpose of the expedition was to make a study of the pearl oysters, which, Dr. Buck had said, abounded in the lagoon, with the view to building a group in the American Museum representing the native divers in the act of gathering them, he became quite enthusiastic and assured us of every assistance in his power.

His most experienced native pilot was then called aft to the wheel, and soon our engines were driving the *Zaca* against the wind toward the narrow entrance, towing behind us Mr. Woonton's boat, as well as a long line of the native dugouts, attached tandem fashion to our stern.

A narrow opening

Very shortly, we were tossing in the midst of a swirl of conflicting currents and foaming whitecaps, as we negotiated the narrow and perilous entrance channel, and then, suddenly, we were quietly riding in the calm turquoise waters of the lagoon. Under the guidance of our pilot, we skirted the luxuriantly green inner shore, rounded a point of land, and soon were floating at the anchorage assigned to us. Opposite lay the picturesque little native village of Omoka, with its simple dwellings nestling under dense groves of coconuts that seemed to crowd every inch of available space. As soon as we had rounded the point, all the inhabitants, men, women, and children, came crowding down to the shore and even invaded the water, paddling around us in their canoes or bobbing about the boat as they swam as near as they dared—for Woonton had warned them to keep at a respectful distance.

Tongareva is a typical atoll, or ring-shaped island of coral, surrounding a central lagoon, one of many such beautiful formations in the South Pacific Ocean. It forms a large oval, eleven miles through its greatest diameter, composed of a series of long, narrow islets, called *motus,* connected by stretches of coral reef, awash at low tide, and absolutely impassable for boats. The waves of the open sea dash against the outside of these reefs with considerable violence, rushing through into the lagoon at high water.

Coral atolls are usually most accessible on their western side, many of them having but this one entrance. Some, however, are completely landlocked, with lagoons that can be navigated only by small boats or canoes carried across the barrier by hand.

All the *motus* of Tongareva are covered with dense growths of tropical vegetation, mostly coconuts. The plantations are almost over-dense, for the natives refuse to thin them out, believing that the value of their land depends on the number of coconuts growing on it. These remarkable trees do not have to be cultivated, as they spring up without any trouble on the part of the inhabitants. They furnish the natives with the material for houses, clothing, mats, cordage, fish nets, food and drink, so they cannot be blamed for considering them as the foundation of their well-being. In fact, the coconuts have also brought the Pacific Islanders a measure of prosperity. For they dry the meat of the nuts to make copra. This is exported in large quantities for the manufacture of soap. The lagoon abounds in tropical fish of all kinds, which form additional food resources, as the islanders are expert fishermen. Finally, Tongareva, like many other Pacific islands, produces the precious pearl oyster, the iridescent shell of which secretes mother-of-pearl and is sold by the ton to trading schooners, to be used for knife-handles, inlays, and pearl buttons. Occasionally, a shell is found which yields a precious pearl, often of great value, enriching the finder, the middleman, and the merchant. As we have said, it was to study these pearl oysters in their native environment that we came to Tongareva.

We found the Tongarevans intelligent and cooperative. They are of the Polynesian race, said, with good scientific authority, to show certain Caucasian traits, doubtless having spread hundreds of years ago into the Pacific Islands from southeastern Asia. There were between 450 and 500 native inhabitants on the island at the time of our visit, mostly living in two villages at opposite ends of the lagoon, known as Omoka and Tetautua, respectively.

Exploring the bottom

Mr. Woonton assigned two natives to us,—Tau, who was the "policeman" of the village, and Toni, a young boy. Both were excellent swimmers and divers, and Tau, particularly, knew all the reefs and shoals intimately.

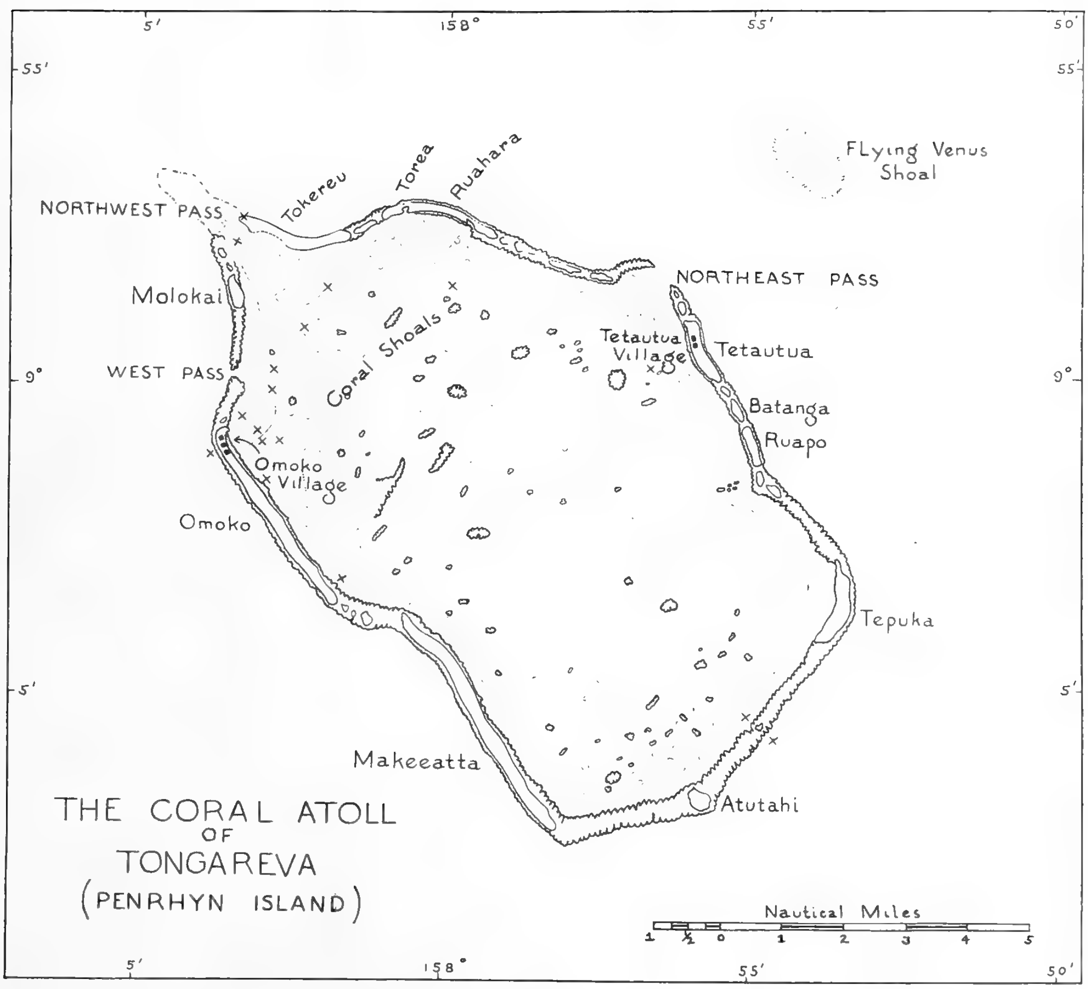
Under his guidance we spent the first two or three days exploring the region in one of the *Zaca's* launches, especially around the coral shoals in the western part of the enclosed lagoon. The waters were very clear, and, using waterglasses (buckets with a glass bottom), we could see the sea floor very clearly for 60 feet or more, and thus were able to pick out the best localities for our undersea investigations. On the third day after our arrival, we were all ready and had our equipment put in order for the work. We then started in earnest and, as we had good weather, we kept on for nine days without a break.

Our method was as follows. Two boats belonging to the *Zaca* were put at our disposal. One of these, an "otter boat," was a small and handy motor launch; the other was a dory. The otter boat carried our photographic equipment,—cameras, undersea camera boxes, and photographic films—, in charge of René, the radioman. Also, Toshio Asaeda, the Japanese artist and photographer of the *Zaca,* was installed here with his sketch blocks and colors, with John, the first mate, as navigator. The dory was reserved for the diving equipment. In it were the two diving helmets with their pumps and hose; the special undersea camera tripods and the hand nets; also, the "bang-bang" (to be explained later), the waterglasses, and the brass-rope ladder. Betts, Olsen, and I occupied this boat with the two sailors who were to man the pumps.

We arrived at our location alongside one of the many shoals. These are interesting growths of living coral composed of many species which, by their combined activity, had grown up from the lagoon bottom, at first as clustered pinnacles, then as broadening columns, which spread out their flat, mesa-like tops within a foot or two of the water surface. The top and sides of these castle-like limestone structures are made up of fragile branching colonies and massive domes of living coral of soft contrasting colors.

The anchors of the dory were thrown out across the top of one of these shoals, thus securing it fore and aft. The otter boat was then lashed parallel to the dory on its outer side. The brass-rope ladder, with rungs one foot apart, was unrolled over the gunwale, to which it was fastened at the top, the lower end trailing over the sea floor 20 or 25 feet below. I was always the first to go down. I stood on the ladder, submerged to my shoulders, while the diving helmet was lowered over my head. The pump was started, and when I felt the stream of fresh air entering the helmet and the comforting clank of the pump beat near my ear, I descended the ladder. Immediately, the 65-pound helmet completely lost its weight as it submerged, and I myself seemed as light as a feather. I climbed down, rung after rung, swallowing as I went to relieve the increasing pressure against the eardrums, and stepped off on the sandy sea floor from the twenty-fifth rung, thus measuring my depth from the surface as 25 feet.

I turned from the ladder and saw before me the precipitous side of the shoal, rising above me in terraces, with overhanging growths of fantastic shapes, adorned with the most beautiful corals imaginable in rich purples, blue, browns, saffron orange and green. Their shapes varied from huge rounded domes to the most delicate lacework, interspersed with contorted fingerlike lobes, gathered in clusters of rich rose. Round about me and above my head flitted fishes of the most gorgeous and weird combinations of color and form, many of them reflecting the sunlight like jewels of coruscating brilliancy and changing prismatic hues. The immediate neighborhood was as transparent as air. I could see fully 100 feet in all directions before the gathering luminous blue fog of the watery distance limited my vision. The undersurface of the water above me gleamed with silver, reflecting like a mirror when quiet, and changing into dancing quicksilver when a breeze threw the surface into ripples and waves.



This typical atoll, 2000 miles directly south of Hawaii, is made up of islets connected by half submerged coral reefs, surrounding an eleven-mile lagoon. The crosses mark the coral shoals where the Museum's undersea studies were made

Photo by Roy Waldo Miner

THE BRAWNY ARMS and magnificent chest muscles of Frank, the Samoan sailor, were always at our disposal for sculling our boats and diving for coral specimens, many of which were huge masses dislodged only with great difficulty

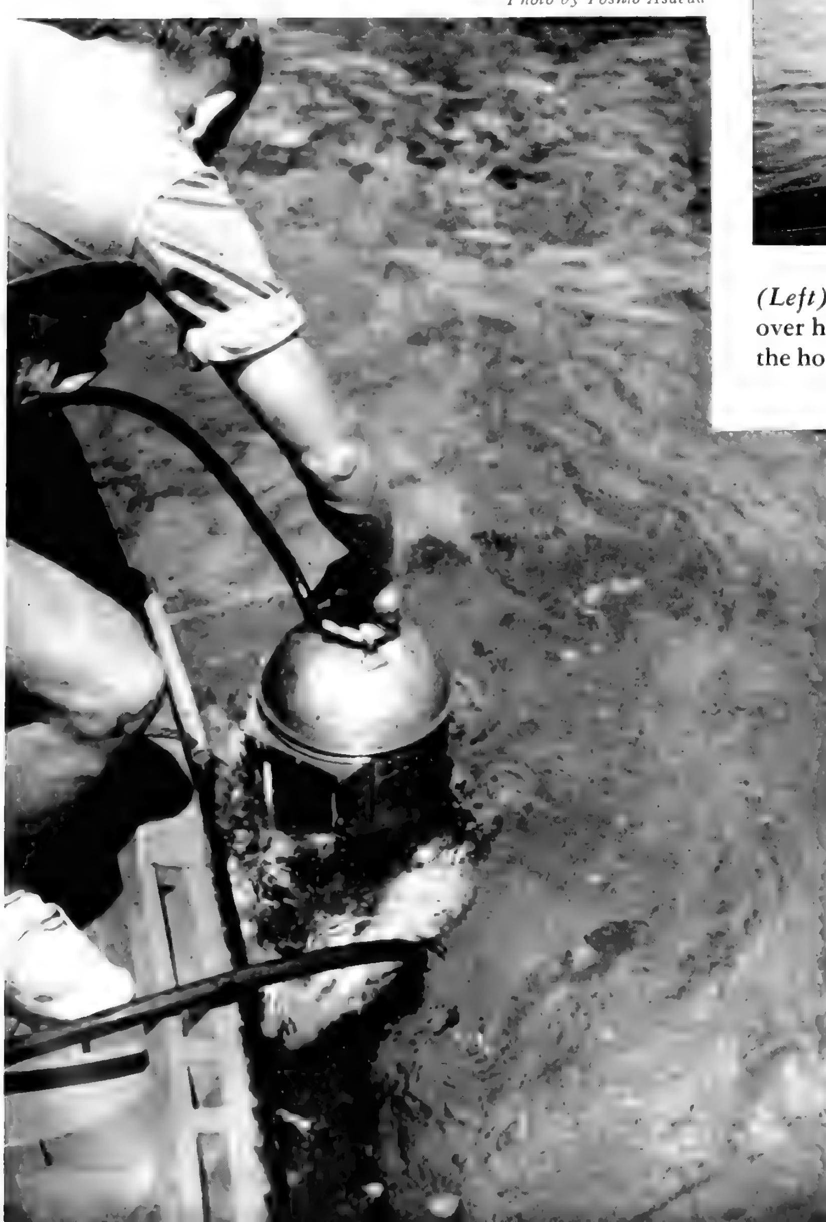
Photo by Wyllys R. Betts

FRANK'S favorite tool was the conventional carpenter's ripping bar, which he used for prying corals from the reef. He is seen above appearing like Neptune from the depths, having climbed to the top of a coral shoal after a 25-foot dive down its precipitous side

(Right) DIVING near a coral shoal to which the boats have been anchored. Doctor Miner is standing on the brass-rope ladder waiting for the diving helmet to be placed over his shoulders. Two sailors stand ready at the air pumps. Wyllys Betts (with goggles) swims near by. The boat contains waterglasses, undersea tripods, and other diving equipment

Photo by Roy Waldo Miner

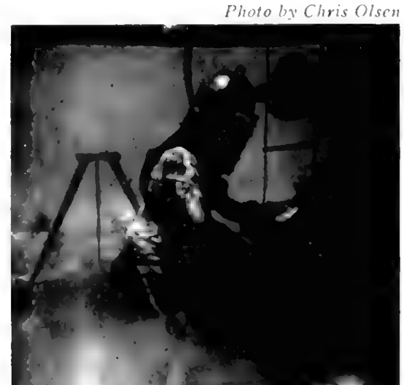
Photo by Toshio Asaeda



(Left) DOCTOR MINER goes down. The diving helmet has been placed over his head, the pump started, and the air, entering the helmet through the hose, keeps the level of the water below the diver's chin. Though the helmet weighs 65 pounds in the open air, it immediately loses weight when submerged. The ladder rungs are set one foot apart. The diver counts them as he descends so as to know the depth at which he steps off the ladder

DOCTOR MINER at the bottom of the sea. The submarine tripod and the rope ladder are visible beyond him. He is examining a cluster of precious pearl shell

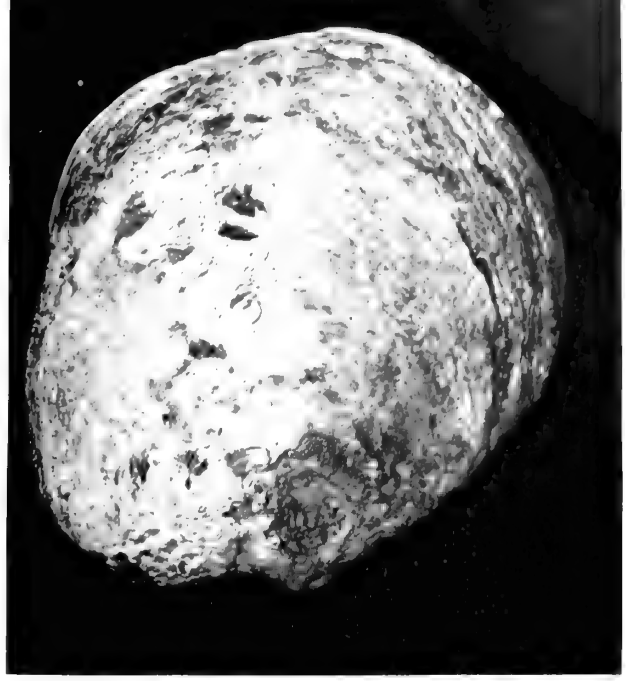
Photo by Chris Olsen



(Right) TAU has just descended with the submarine camera. After placing it on the tripod, he swims to his favorite pinnacle to watch the photographic operations

Photo by Toshio Asaeda

(Above) Two divers are down, as shown by the double line of hose, the patches of bubbles, and the shadowy diving helmets visible through the disturbed but clear water



AMNH photos by Coles

Typical Pacific pearl shell. The outside *(above)* is rough and shows encrustations and growth lines. The interior *(below)* is lined with iridescent nacre or mother-of-pearl

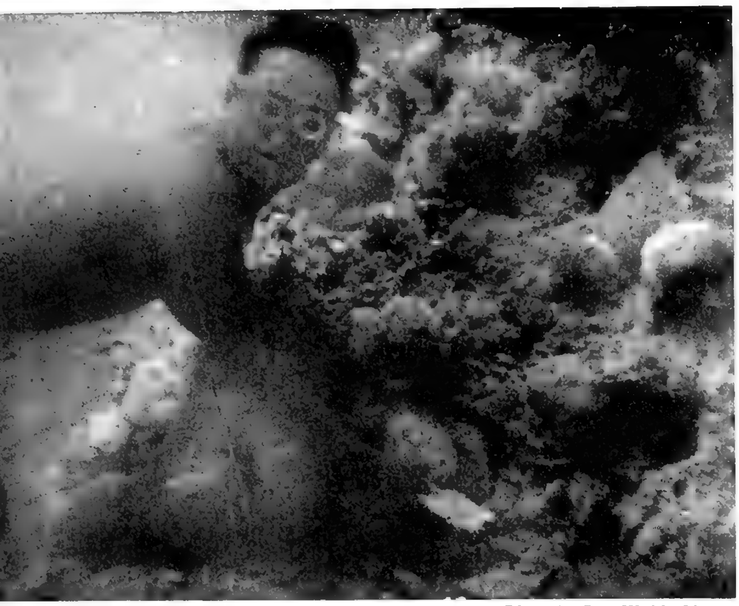
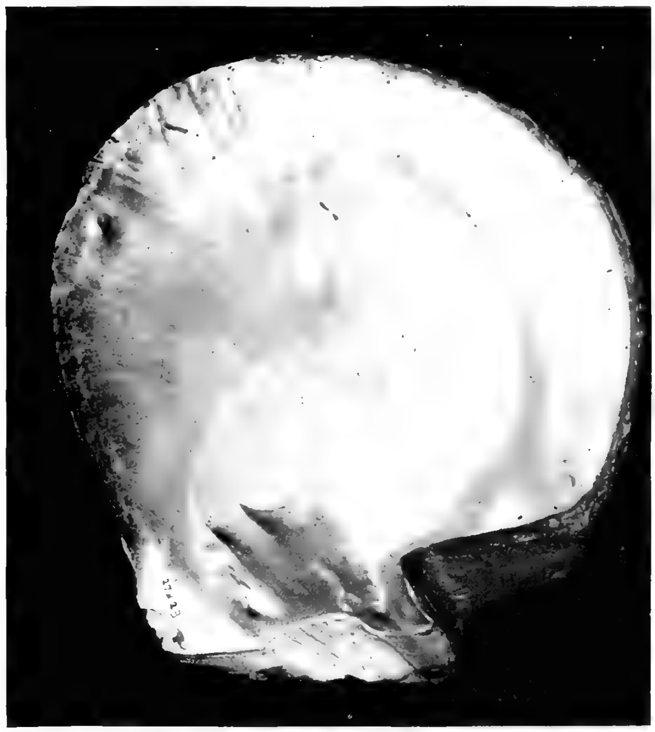


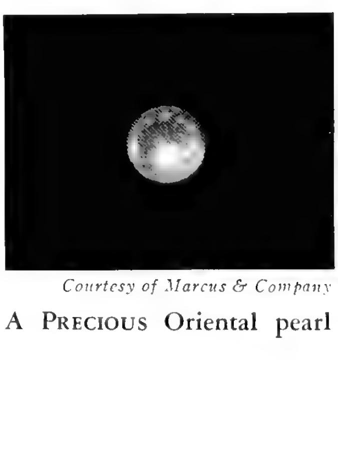
Photo by Roy Waldo Miner

Tau, the Tongarevan diver, has discovered a large cluster of pearl shell and calls the submarine photographer's attention to his find, as he severs the tough byssus threads by which they are attached to the sea bottom. The amphibious Tau stays at the bottom three or four minutes at a time. He rises to the surface at intervals to renew his air supply, returning immediately to his search for the pearl shells which grow abundantly in the lagoon



(Below) Chris Olsen painting undersea. An oiled canvas stretched over plate glass is framed in a metal easel. Oil colors are pressed on with a palette knife

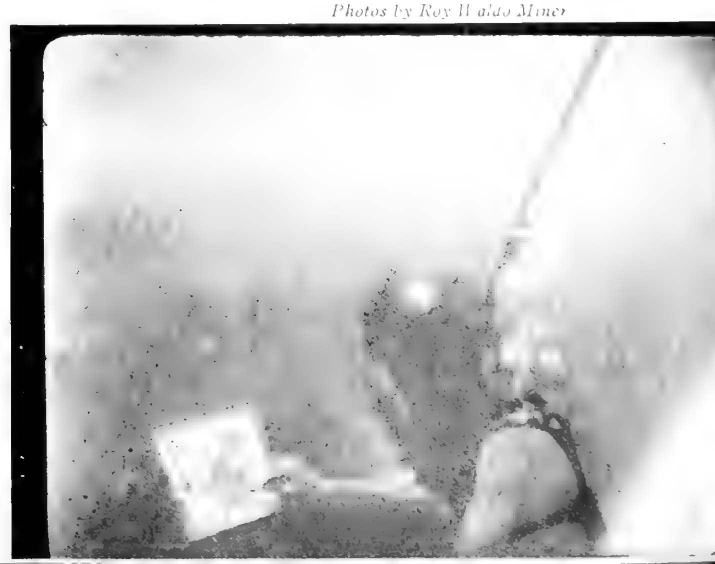
Photo by Roy Waldo Miner



Courtesy of Marcus & Company

A Precious Oriental pearl

Photos by Roy Waldo Miner



I took a step forward, half floating. A push of my foot sent me in a gentle, slow-motion stride over a pinnacle as high as my waist, and I settled down on the other side, my toes balancing on a great purple dome as lightly as thistledown.

Undersea photography

The silvery water surface above my head broke, and the legs and square top of my tripod appeared, pushing through with a cloud of bubbles as it hung grotesquely from a hook at the end of a cord. It was lowered with a series of irregular jerks to the sea bottom a few feet away. I made my way over to it deliberately with half-floating steps, allowing the pressing watery medium to support me as I did so, instead of wasting strength in trying to push it aside. When I reached for the tripod, my hand closed on nothing, for the magnifying quality of the water deceived my eyes in estimating distance. I groped toward it, in full vision, and watched my hand finally close about it like the hand of another person. Slowly I placed the tripod in position; and then I saw, hanging near by, one of the loaded camera boxes with motion-picture camera enclosed. I placed it on the tripod, took note of the distance for which it had been focused chalked upon its side, and signaled with my arm toward the lower end of a waterglass through which John was gazing weirdly down at me from above.

The surface water broke again, and a coil of line, weighted with lead sinkers, floated down to me. I fastened one end of this to the coral growth toward which the camera was pointing and measured the distance to my lens, counting the sinkers which had been attached at measured intervals for that purpose. I adjusted the tripod and camera, pressed the lever that connects with the shutter within, and ran off the film for a motion picture of the submarine vista with the strange and beautiful fishes that came flitting, like actors, across the coral stage. I repeated this in various directions until the film was completely exposed. I looked up to signal again and saw the legs of Tau, the diver, hanging near the boat. I raised my hand, and immediately he let go and sank down near me with another loaded camera box. He set it on my tripod, in place of the first, which I was now holding in my hand. Then he relieved me of my burden, and, with a push of his foot against the sea floor, swam vigorously to the surface, heavy box and all, to deliver it to the waiting hands of John. In a few minutes, Tau was down again and swam over to a neighboring pinnacle to which he clung, so as to watch me at his leisure. He rose to the surface occasionally when he needed air, but he always returned to the same spot to wait until my camera ran down, when he swam over to get it and take it again to the surface. He seemed like a veritable amphibian!

Now, down the ladder, came another pair of legs. It was Olsen, equipped with the other helmet. In his hand he had a nonrustable metal palette, with oil colors arranged around its margin in the conventional manner. When he reached the sea bottom, he waited until an easel of the same metal was lowered, framing a sheet of plate glass with oiled canvas stretched over it. He then carried this outfit a short distance away, set up his easel on a rock, and, standing before it, looking like a hobgoblin in his diving helmet, proceeded to lay oil colors on the oiled canvas, pressing them down with his palette knife, thus painting undersea the color and arrangement of the coral formations!

I turned my camera toward him and made a motion-picture record of this unusual performance.

Octopus

On the sea floor, a short distance away, I now espied a fine cluster of living pearl oysters. I went over and examined them carefully. Returning to the camera, I made a careful photograph of them and of several other clusters which I discovered nearby. I signaled again, and Tau came swimming down. I pointed out the pearl oysters, and he swam over, separated them from the coral rock to which they were fastened by means of their tough byssus, and bore them to the surface in his arms. Meanwhile, all this was recorded by the camera. Olsen had now gone above, and Betts took his place. He came over and touched my arm to draw my attention to the side of the cliff, where an irregular cavern opened above a threshold of coral. A tapering serpent-like tentacle was sliding out over the rounded surface, followed by another and another, all armed with disk-shaped suckers! Immediately behind them a bulb-shaped head erected itself above a pair of baleful eyes, regarding me with basilisk-like stare. I turned to my camera, but the film had run out. I signaled for another, and it was quickly lowered to me. I made the exchange as rapidly as possible, meanwhile keeping an eye on the octopus. While I was thus engaged, the creature slid forward over the coral head, bringing all eight of its tentacles into view. Suddenly it launched forward into the water, bulb-shaped head foremost and tentacles streamlining out behind, and swam over to another ledge a little farther away. Meanwhile, I was struggling to adjust the new camera, but when I had it in position, to my disgust, the

creature slipped around the shoulder of the cliff and vanished. Another opportunity lost! However, we later captured several others and were able to study them at close range in the aquarium on the deck of the *Zaca*.

Now for the "bang-bang"!

Many of the gorgeous butterfly fishes, goatfishes, filefishes, and scarlet-spotted tangs eluded all the usual methods of capture, so I had to fall back on this unusual apparatus. It consisted merely of a bamboo pole about ten feet long, carefully weighted and balanced with sheet-lead, and having at its end a couple of dynamite caps. Attached to these, a long insulated and waterproofed electric cord was looped along the pole, passing through my hands, and extending 30 feet upward to the boat, where John sat with a switch box between his knees. I would walk along the sea bottom in my helmet, holding the pole out in front of me, stalking the fish I wanted. When I managed to get the caps about a foot above the head of a gaily colored butterflyfish, I would jerk the cord, as a signal to John, who would then close the switch. There would be an explosion, and the fish would flop over, stunned but not killed. Meanwhile, Tau would be swimming at the surface, with a hand net, watching me through the goggles that he always wore undersea. As soon as he heard the explosion, he would swim down, capture the fish in his net, swim to the surface, and turn it over to Toshio, who was waiting in the launch. The Japanese artist would quickly put the fish into a pail of sea water, where it would soon recover. Meanwhile, he would make an accurate record of its color pattern, while still in its fresh condition, before captivity had caused it to fade, as is often the case. This process was repeated again and again. When we returned to the *Zaca,* Toshio would make finished paintings, utilizing his sketches as data, while Olsen and Betts would make plaster molds of the fish. Later, when we reached the Museum, we made wax casts of the fish from the molds, which could then be colored from Toshio's paintings to make life-like replicas of the fish.

That all can see the diver's world

For nine successive days we made trips of this kind to all parts of the lagoon, according to the plan we had evolved when we arrived. We dove morning and afternoon, staying down in the warm transparent waters as long as we wished. I made more than 70 dives during that period, and Olsen and Betts kept the other helmet just as busy. We took thousands of feet of undersea film, made hundreds of sketches of the living fishes and corals in color, secured scores of pearl shells, ten tons of beautiful corals, and specimens of many other invertebrates, as well as notes of many original observations. While we were working, we saw plenty of sharks, morays, octopuses, and poisonous starfishes, and had some interesting experiences with them, but, fortunately, nothing of a serious nature occurred.

Our largest and finest coral is a beautiful spiral growth weighing 900 pounds and measuring five feet in diameter. This is now a conspicuous feature in the Pearl Divers Group in the Hall of Ocean Life of our Museum. We also photographed the native divers while they were collecting pearl shell and made careful photographic studies of them ashore, from which life-size models were afterward constructed for the group.

A submarine fairyland

The Pearl Divers Group, which has been built as the result of this expedition, is now on public exhibition. It has involved much precise and unusual technique to produce it on the part of the artists and modelers of our Department of Living Invertebrates. It represents two Tongarevan pearl divers plunging down into a coral gorge, faithfully reproduced from one of the magnificent formations that we actually visited on the sea floor of Tongareva. In the midst of this submarine fairyland, they are engaged in plucking precious pearl shell clusters from the ocean bed, daring the menacing octopus sliding out from the entrance of a mysterious sea cave. The divers swim and grope past beautiful and grotesque coral growths to find their prizes among sea gardens of stone flowers, glowing in all the soft colors of the spectrum, while fishes of every gaudy hue dart past them. Beneath the great spiral acropore coral in the center lurks a scarlet, sixteen-pointed sea star with hundreds of poisonous spines menacing from its upper surface.

Among the corals on the bank toward the left, may be seen a bed of furbelowed *Tridacna* clams with sinuous openings, festooned with gaily colored mantle-edges. These are the man-trap clams, to be avoided by the hands or feet of the swimmers, lest the unwary diver be caught and held between the vise-like valves.

Over on the right, the visitor is given an opportunity to peer through a special opening into the Cave of the Octopuses, to spy upon the grisly inhabitants at home, while a vista into the distant waterworld is glimpsed through a submarine tunnel.

The group, as a whole, reproduces a characteristic association of sea creatures typical of the coral reefs of the tropical Pacific and illustrates one of the more primitive methods of fishing for precious pearls.

(*Left*) UPPER SURFACE of a shoal of living coral photographed through two feet of water. The anchor rope of the work boat is visible across the shoal at the left of the picture

Photos by Wyllys R. Betts

(*Left*) EDGE of above shoal with closer view of the coral growths. The water is so transparent that clusters are visible even at a considerable depth

(*Below*) A LIVING *Tridacna,* the furbelowed or man-trap clam. Between the slightly open valves of the shell may be seen the thin membrane of the mantle cavity pierced by two mantle openings. The oval margin of the left-hand aperture is visible, showing the mottled lining of the mantle cavity within. The thick edges of the mantle, adorned with multitudes of thin, brilliantly blue stripes, are expanding over the scalloped edges of the shell

Photo by Toshio Asaeda

(Above) PART of the coral collection of the expedition, assembled on the dock at Tongareva after having the outer animal tissue removed

(Below) THE largest coral collected, weighing 900 pounds. Secured with difficulty by Frank Tiaga and two Tongarevans, it is shown here being hauled aboard the *Zaca* after being brought from across the lagoon. The entire coral mass is five feet in diameter and now forms an important feature of the Pearl Divers Group in the Museum

Photos by Toshio Asaeda

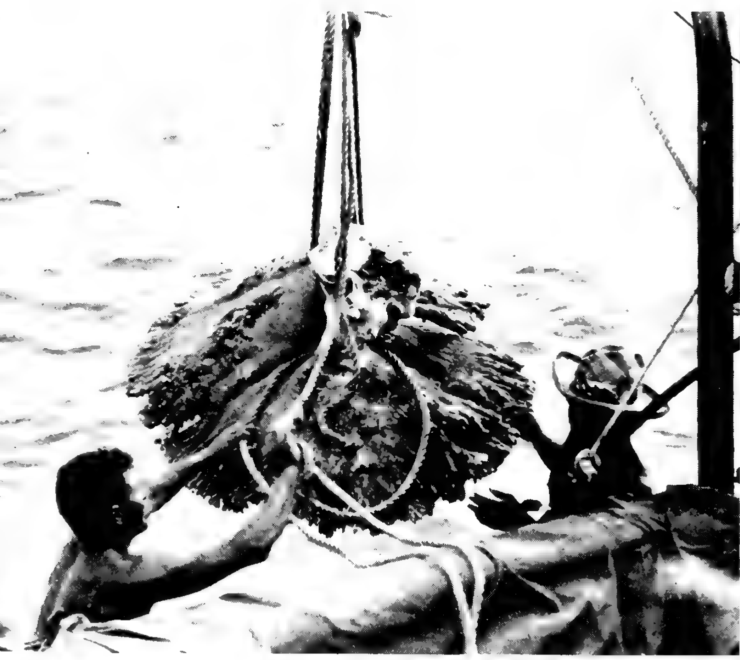


Photo by Roy Waldo Miner

(Above) THE GREAT acropore coral specimen aboard the *Zaca.* Its unusually symmetrical form and the spiral character of its growth are well displayed in this picture. This coral, together with the rest of the collection, was brought to Pago Pago, Samoa, on the *Zaca.* Two Samoan natives are seen in the distance

(Left) THE LARGE CORAL being permanently packed for shipment to the Museum. Its bottom was carefully secured and the specimen braced against the sides of the box, while they were being built around it

(Below) FRESHLY collected corals were brought aboard the *Zaca* at Tongareva, placed in tubs of sea water and thoroughly washed by hosing to remove the animal tissue covering the outer surface. This is known as "bleaching"

Photo by Toshio Asaeda — *Photo by Wyllys R. Betts*

(Right) THE COMPLETE COLLECTION on dock at Pago Pago, still roughly packed as it left the *Zaca.* The skilled sailors at the Naval Station carefully crated the entire ten tons of material for shipment to the United States. The collection included corals and hundreds of pearl and *Tridacna* shells. In the foreground may be seen plaster molds made directly from the fishes collected for the group

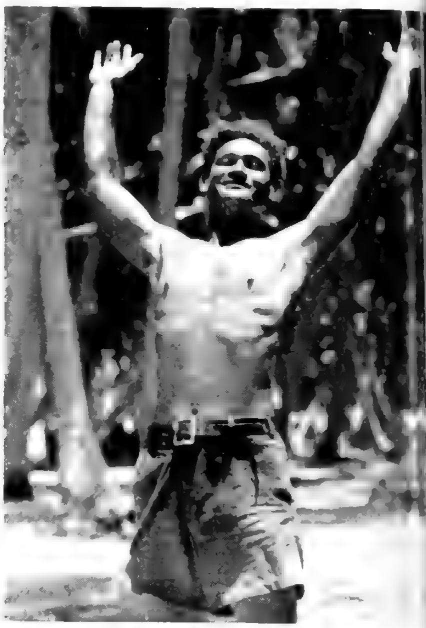
Photo by Toshio Asaeda

AMNH photo by Coles

(Left) A DETAIL of the completed Pearl Divers Group. A native diver, equipped with goggles and simply clothed in a *parieu* twisted about his loins, is detaching clusters of pearl shell from the sea floor at the bottom of a beautiful gorge in the lagoon of Tongareva. Near by, an octopus glides out from a crevice overarched by precipitous walls of fantastically eroded limestone covered with delicately branching growths of coral, alternating with massive domes and grotesquely weird foliations. Brilliantly colored fishes flit in and out of the sea caves

The group was constructed, under Doctor Miner's direction, by Chris E. Olsen and Bruce K. Brunner, assisted by Dr. George H. Childs and Worthington H. Southwick. The life-size figures of the pearl divers were modeled by John W. Hope

(*Left*) A NATIVE gracefully plunges into the depths of the coral fairyland in search of pearl shell. The spiral turret of the great acropore coral, the prize of the collection, is shown in place in the lower right-hand corner of this view of the finished group



(*Above* and *below*) CAREFUL photographic studies were made of the Tongarevan natives from which the Museum sculptor constructed the life-size figures of the divers

Photos by Toshio Asaeda

AMNH photos by Coles

(*Left*) Through an opening at right side of the Group is depicted a vista through the cavern of the octopuses. A grisly individual is gliding menacingly down from the rocks above

The expedition was made possible by Templeton Crocker and his yacht, ZACA. The group itself is the gift of the late Edith Haggin de Long.

The expedition personnel consisted of Doctor Miner, Wyllys Rosseter Betts, Jr., and Chris E. Olsen.

Issued under the direction of the
Committee on Popular Publications
Roy W. Miner, *Chairman*

CANYONS
UNDER THE SEA

By HAROLD E. VOKES

THE AMERICAN MUSEUM *of* NATURAL HISTORY

CANYONS UNDER THE SEA

By

HAROLD E. VOKES

GUIDE LEAFLET SERIES
of
THE AMERICAN MUSEUM OF NATURAL HISTORY
No. 105

Each year many New Yorkers, as well as multitudes of people from other parts of this country, journey long distances at considerable expense to view the wonders of the Grand Canyon of the Colorado River, never knowing that within 130 miles of Manhattan there is a canyon about 50 miles long that is comparable to the Grand Canyon in depth, and probably more spectacular in appearance in that it is less than half as wide at the rim. We cannot compare the two in scenic effect. We do not know whether the marvelous coloring of the rocks of the Grand Canyon region is duplicated here or not, for no one has ever seen the canyon! It is a submarine canyon whose rim is 500 feet below the surface of the Atlantic, and whose mouth lies at least 8400 feet deep.

Although the Hudson Submarine Canyon has never been seen, it has been quite accurately mapped during the past decade by the United States Coast and Geodetic Survey. The scale model of it, shown in the accompanying illustrations, has recently been completed in the American Museum of Natural History and is now on exhibition in the Hall of Ocean Life.

The existence of the canyon has been known for only a little more than half a century. It was in 1885 that Captain Lindenkohl of the United States Coast

CANYONS UNDER THE SEA

By H. E. Vokes

[illegible] The American Museum of Natural History

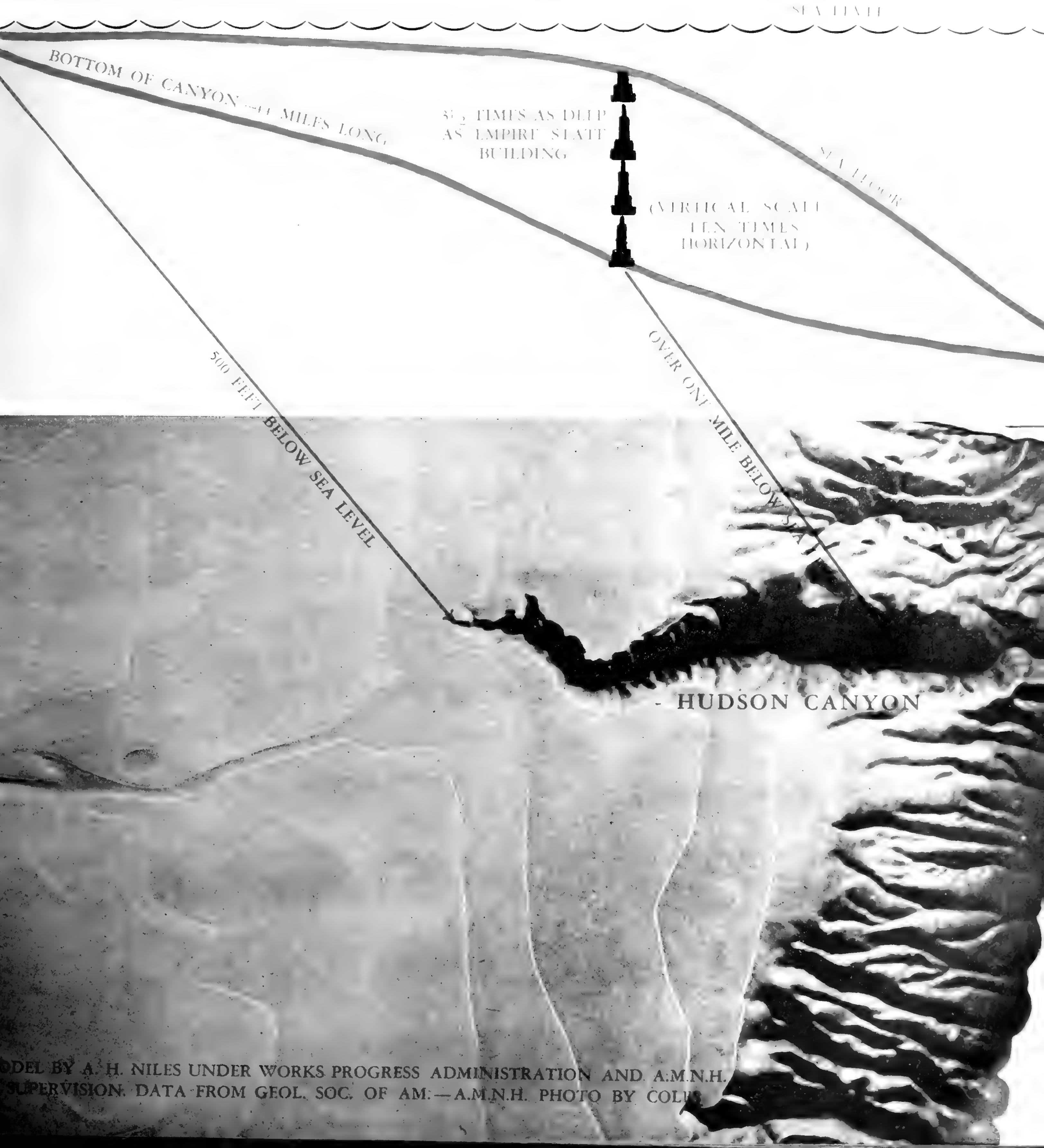
Equal to the Grand Canyon in depth and having more precipitous sides, Hudson Canyon remains one of the great mysteries of the deep, for it represents a strange family of submarine features which no scientific facts can explain

and Geodetic Survey first announced that a *ravine* had been found at the edge of the continental shelf, near the end of the known submarine channel of the Hudson River. Only recently have deep-sea sounding methods demonstrated that such depressions are common features along the margin of the continental shelf and that they possess a depth and length such as to make the term "ravine" hardly appropriate.

UDSON CAN-
ON BEGINS
30 MILES
ROM NEW
ORK CITY

On land, canyons are found cut into highland areas, either in mountains or plateaus. Their mouths are always at the lowest part of their course, generally where the highland slopes to join the lowland. They are almost invariably formed by moving water, either that of flowing streams, or by water frozen to form the ice of glaciers.

In the sea, the canyons are found in somewhat similar "terrain," being cut into the margins of the continents where these drop off into the true ocean basins. One is likely to consider that the edge of the continent is where the land dips beneath the sea. Scientists have long recognized, however, that the continents are great uplifted blocks, whose real margins lie some distance out from shore, at a point where the bottom drops off rather abruptly to the true ocean basin. In other words, the surface of the continent passes gradually beneath the surface of the sea



ODEL BY A. H. NILES UNDER WORKS PROGRESS ADMINISTRATION AND A.M.N.H. SUPERVISION. DATA FROM GEOL. SOC. OF AM.—A.M.N.H. PHOTO BY COL

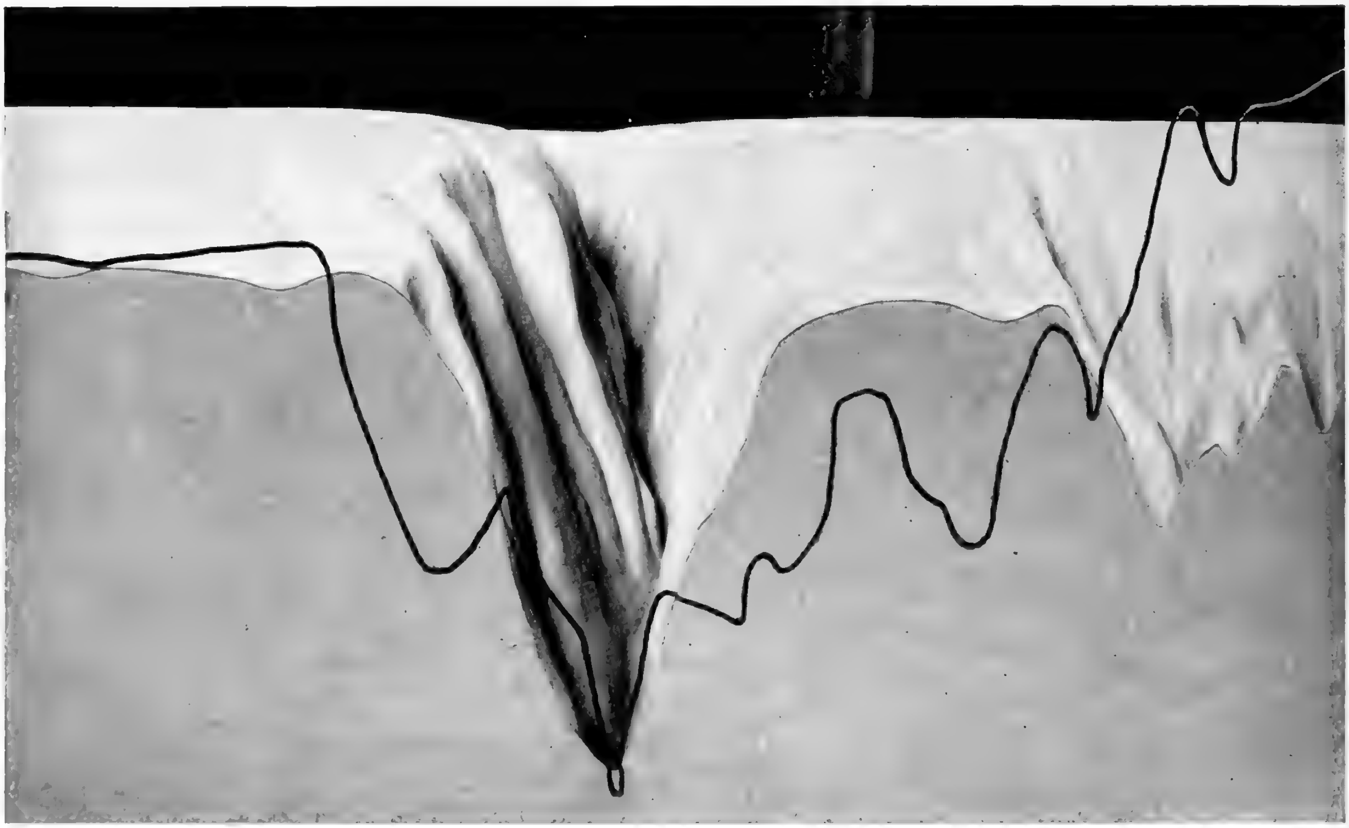
to a depth of approximately 600 feet in most places, at which point a sharper slope occurs. The submerged edges of the continents are referred to as the "continental shelves," and the submarine canyons are all cut into the shelves along their outer edges. The new model, which shows the shape of the margin of the continent in a very graphic manner, is eleven feet long and three and a half feet wide. It represents an area 164 miles long and 53 miles wide and was constructed in the Department of Paleontology with the assistance of the Works Progress Administration, the work being done under the supervision of the writer.

Submarine surveys made during the past few years have indicated the presence of a great many canyons similar to the one shown in the model. At the present time canyons are known to occur off all the edges of the continents save on the Arctic and Antarctic slopes. Their apparent absence is probably due to a lack of adequate surveys in those regions rather than to any considerations having to do with their method of formation.

Many of the canyons occur off the mouths of rivers, those off the Hudson River in North America and the Congo River in Africa being among the most spectacular. Others occur off the Ganges, Indus, Niger, and Columbia Rivers, as well as a multitude of smaller streams. This general alignment led to an early suggestion that the canyons had been cut by these rivers at some time when the continental margins were much higher in relation to the ocean level than they are today. But the recent investigations have shown that there are many gorges that cannot be related to any modern river. One of the more interesting canyons of this type begins almost at the head of the pier at Redondo Beach, California.

When canyons of this sort first became known it was suggested that they might possibly be very old features, perhaps dating even from 200 or 300 million years ago, in the Paleozoic era, and that all evidence of the eroding rivers had been destroyed in the subsequent eras. But within the past five years we have learned that the canyons are cut into rock containing more recent fossils (Cretaceous and Tertiary), and it is now realized that the canyons are young structures, geologically speaking, probably not older than the Pleistocene or glacial period of approximately a million years ago.

The suggestion was then offered that the amount of water frozen to form the glacial icecaps of that period might have lowered the sea sufficiently to permit the rivers to cut the gorges, and that the tilting of the continents under the weight of the glacial ice had so deflected the courses of the rivers across the continental shelf as to permit their cutting the canyons which today cannot be related to any present river course. For example, a large canyon, the Wil-



AMNH photos by Coles

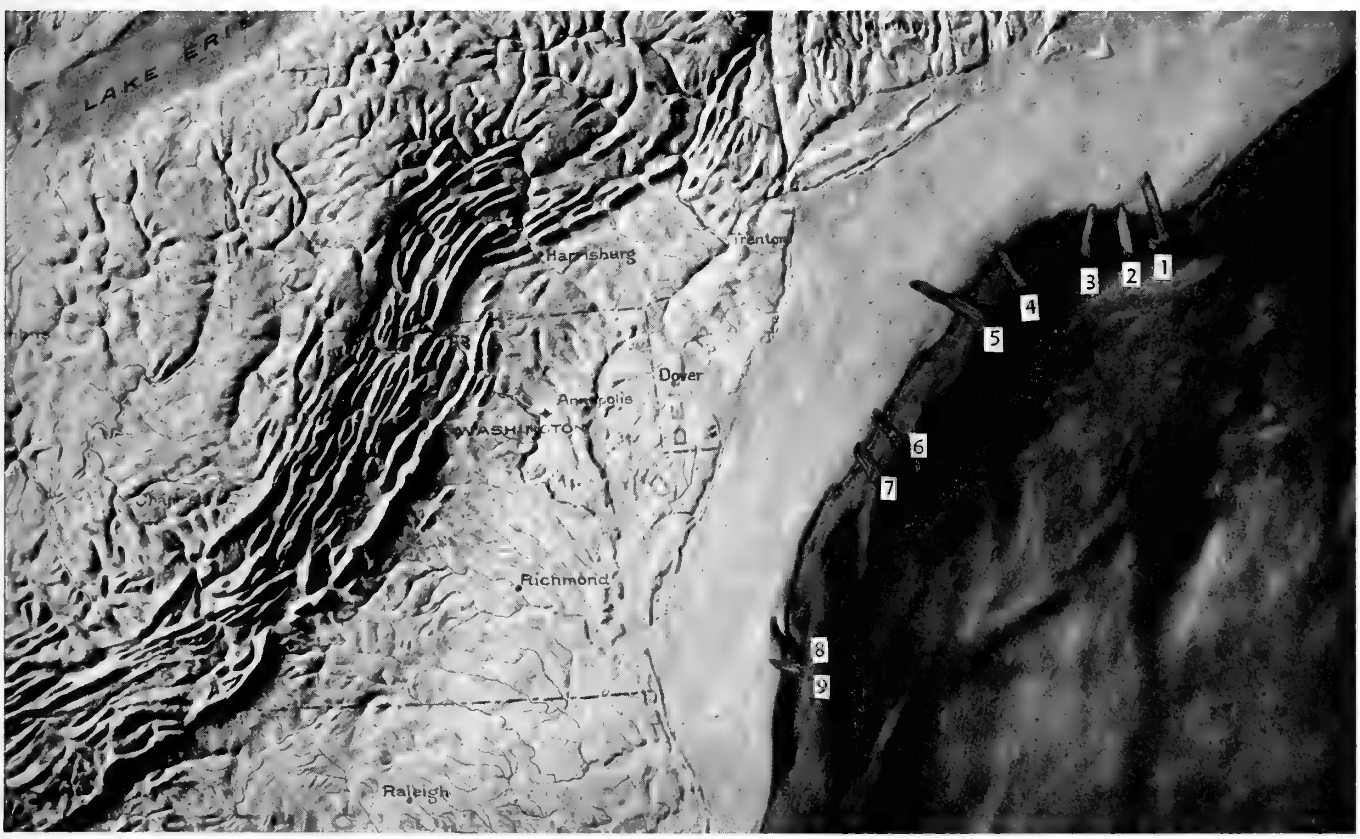
HERE a line representing the cross section of Grand Canyon is placed against the cross section of the model of Hudson Canyon. Note that the canyon 130 miles offshore from New York City has almost the same depth but much steeper sides. (Both profiles show the vertical distances ten times the horizontal)

mington Canyon situated slightly northeast of Cape May, has been attributed to the eroding power of the Hudson River during one of the earlier glacial advances, while the present Hudson Canyon has been attributed to the erosion of this river during the last glacial advance. Numerous careful studies have indicated that the level of the ocean surface was indeed lowered by the water frozen into glacial ice, but all the evidence suggests that such a lowering cannot have been more than 300 feet. This is still some 200 or more feet above the level of the heads of most of the canyons, and no known river today has sufficient current to erode any such structures off its mouth at these depths.

It has been argued that we are misinterpreting the evidence and that the surface of the sea may have been lowered much farther than has been supposed. In answer to this, Professor Shepard of the University of Illinois has pointed out that the valleys extend to a depth of one or more miles and that the removal of enough water from the oceans to permit land at those depths to be cut by rivers would require the storage of about one-half of all the water in all the oceans and the piling up of an icecap at least fifteen miles thick on the continents. This seems impossible and is incompatible with all the evidence.

If the level of the sea was not lowered, perhaps the land itself rose, allowing the canyons to be cut, and then sank back beneath the sea. The amount of up and down movement necessitated by this suggestion is rather staggering to the imagination of the geologist. It would have had to occur along the margins of all the continents, and the amount of uplift would have to have been approximately equal everywhere, and the depression the same. One cannot conceive of such uniformity, geologically; furthermore, it is impossible to believe that such disturbances of the earth's crust could have occurred without leaving their mark on the adjoining lands, and there is no evidence suggesting such gigantic disturbances.

Despite the number of objections which have been raised against the possibility that the gorges were formed by river erosion, a number of students still believe that the true explanation of their origin will be found in this hypothesis. A multitude of other suggestions have been offered to explain the canyons. The recent great increase in our knowledge of their distribution and physical characteristics has shown that many of the earlier suggestions are wholly untenable. There are, however, still some five or six hypotheses which are receiving serious consideration by scientists engaged in the study of them. But there remain so many pertinent and significant objections against the acceptance of any of these that it seems probable that the correct explanation of how these gorges were formed (or are now being formed) has not yet been proposed.



Based on Plate I, Geol. Soc. America, Special Public, No. 7; Veach and Smith: Atlantic Submarine Valleys . . .

As elsewhere along continental shelves, a number of canyons are known to exist off our eastern coast. The canyons shown above are: (1) Hydrographic Canyon, (2) Veach Canyon, (3) Atlantis Canyon, (4) Block Canyon, (5) Hudson Canyon, (6) Wilmington Canyon, (7) Baltimore Canyon, (8) Washington Canyon, (9) Norfolk Canyon

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Roy W. Miner, *Chairman*

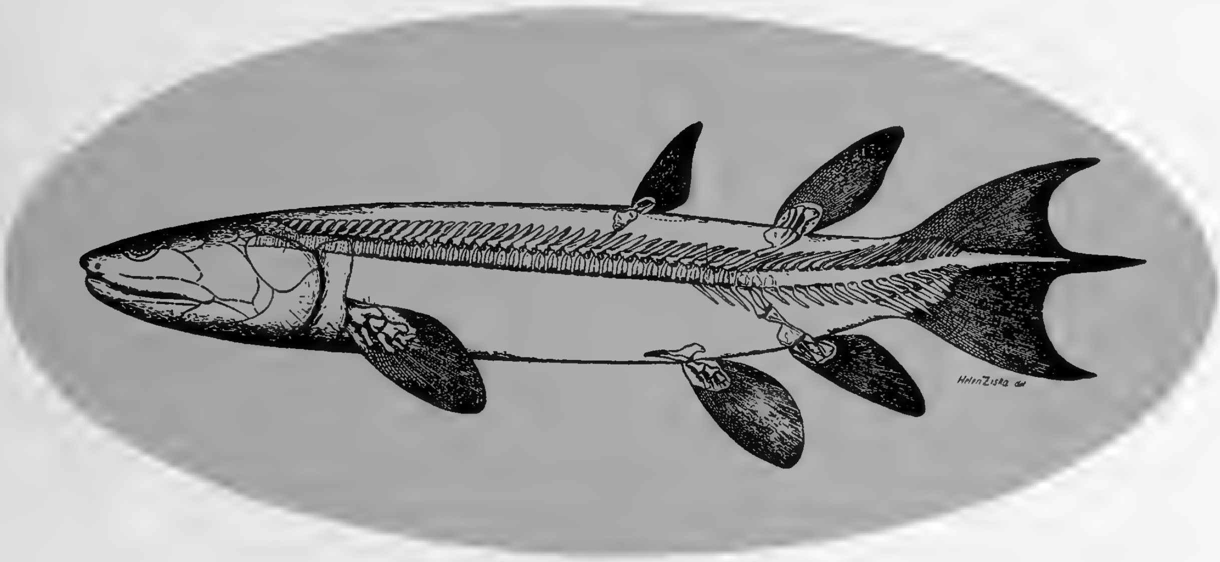
FAMILY TREE OF THE VERTEBRATES

Grandfather Fish and His Descendants

By

WILLIAM K. GREGORY

Curator, Departments of Fishes and Comparative Anatomy



GUIDE LEAFLET SERIES

of

THE AMERICAN MUSEUM OF NATURAL HISTORY

No. 106

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No. 106

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After Lankester

(Left) "GRANDFATHER" of 50,000 species of living animals and countless extinct ones: the 400 million-year-old "shell-skinned" fish, Cephalaspis. Its ground plan is seen to develop through successive evolutionary stages to provide the complex bodily features of all the modern fishes, amphibians, reptiles, birds, and mammals

(Above) ANOTHER LIVING FOSSIL descended from Grandfather Fish: the lamprey, front and side. Its efficient suction disk has permitted the lamprey to survive down to the present day in spite of its refusal to adopt a modern body design. Lampreys are sometimes popularly called eels, but in the tree of life they are farther from eels than eels are from man

Twenty-four centuries ago, the Greek philosopher Anaximander said that men were first produced in fishes and when able to help themselves were thrown up to live upon

GRANDFA

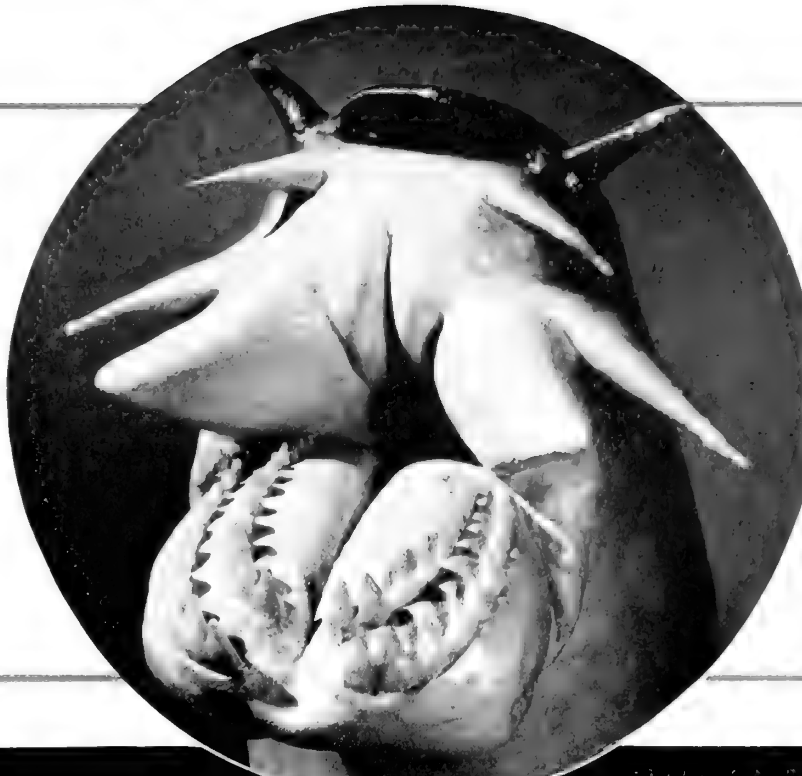
By WILLIAM K. GREGORY

Curator, Departments of Fishes and Comparative Anatomy, The American Museum of Natural History

GRANDFATHER FISH lived so long ago that his personal history might seem to be of small importance to his remote descendants. Very few of them have ever heard of him anyway, and if they did they would promptly disown him. The very idea that man has been derived from a fish might seem to them even more fantastic than that man's ancestor was a monkey.

In this article we are not attempting to set forth the evidence for the reality of Grandfather Fish, for that evidence is scattered among thousands of facts and recorded in hundreds of books and papers. Neither are we assuming momentarily an improbability merely to lead to something better. We are only trying to sketch the introduction to a factual history covering several hundred million years in the transformation "from fish to man."

(Right) A VAMPIRE of the sea with an illustrious lineage. The modern hagfish is a "die-hard" that retained many of Grandfather Fish's basic features and survives today as a veritable living fossil. It lacks the true jaws of modern fishes and uses outmoded pouch-like gills. In place of a backbone, it has an elastic notochord. But it has developed a full kit of burglar tools for rasping a hole in the body of a fish and sucking out its blood. The portrait shown is from a model on display in the American Museum of Natural History. Directly below is a side view of the same creature



All photos by AMNH

the land. Modern science, piecing together the factual story, finds that this ancient theory was surprisingly farsighted. Here the celebrated author of *Our Face from Fish to Man* tells the first chapter in the evolution of backboned animals. Other chapters on the history of animal life in North America by various authors will appear in future issues

THER FISH and his descendants

Before we begin that history we must glance for a moment at its sources and documents. Broadly speaking these are: (1) paleontology, or the science of ancient life; (2) living animals, their zoology, embryology, and comparative anatomy, and (3) such newer sciences as experimental biology.

As to the documents of evolution, confusion has sometimes come from the very wealth of the evidence. There are estimated to be over 50,000 known species of backboned animals still existing, and if the known fossils are added, the number becomes even more bewildering. But there are easily available clues to this labyrinth.

Every beginning student in zoology is taught the rudiments of the classification of animals. He is expected to know that the smaller divisions, such as varieties, subspecies, and species, are combined in an ascending scale into larger groups called genera, and that these in turn are built up into progressively wider and more comprehensive assemblages called families, orders, classes, superclasses, and phyla. But what the student may not realize is that any individual cat, for example, besides being a sample of the species, also has the physical characteristics common to all members of the cat *family,* and, in decreasing numbers, those of the *order* of carnivores, of the *class* of mammals, and of the *phylum* of vertebrates. As a rule the popular mind as recorded in common speech thinks of one thing at a time and has a special name for it: cat, dog, bear, skunk, etc. And among specialists the idea has gained credence that the most important kind of knowledge is that which expresses the finer differences between different varieties of the same general kind. But when we study individual animals as representatives of larger groups, we find that the characteristics common to a broad division of animals, such as a class, are mostly older in the evolutionary story than those of the smaller division known as the family, and that the latter are in turn older than those of the genus, and so on down to individual peculiarities. This is like saying that the human race as a whole has had two arms and two

legs for a long time, but that the peculiar chin of the Jones family or the red hair of the Smiths is not an ancient or fundamental feature of the human race. The remains of ancient animals dug up by fossil-hunters show that the same principle holds true in the tremendously long story of animal evolution.

Thus the classification of living animals into broad and narrow divisions gives a fairly clear indication as to which characteristics are older and which are younger, and provides a helpful key to the history of animals, especially when used in connection with the fossil remains of the animals themselves.

The chart occupying the center spread of this issue of NATURAL HISTORY shows the important position that Grandfather Fish holds in the history of evolution. This chart will be found useful in connection with other articles that will appear in NATURAL HISTORY dealing with other chapters in the story of the origin of our animal life in North America. Here only 81 animals have been selected from the thousands that have made their appearance along the stream of time, but these few samples represent most of the main divisions of animals concerned.

The broader lines of descent and relationship are shown on the chart by the main branches and by the larger lettering. How have we discovered these lines? They are gradually coming to light as almost unexpected by-products of the exploration of hundreds of localities yielding fossils in many parts of the world. Nobody, for example, dug fossils anywhere with the purpose of proving that the most ancient and primitive fishes were the ones known as the ostracoderms, or "shell skins." Indeed, these shell-skinned forerunners of the true fishes were long thought to be "specialized and extinct side branches" of the supposedly unknown ancestral stock of the vertebrates. But, thanks chiefly to the later explorations of the Danish East Greenland Expedition and to the intensive work of Doctor Stensiö of Stockholm, it is coming to be realized that the ostracoderms as a whole have the basic requirements for this key position in evolution. This means that we may properly search among them for Grandfather Fish,—the type of fish that is responsible for all the hosts of backboned animals that today inhabit the land and waters. With regard to the many intervening types of vertebrates, whether or not we know their *exact* ancestors and descendants in each case, we are getting better and better evidence of what led up to them and where they belong in the general sequence of events.

Finally, we have certain animals on earth today that are conservative "die-hards,"—"living fossils" which have lagged behind their progressive relatives and retained for our inspection much of the internal ground plan of their remote ancestors. Among living creatures, the lampreys (often wrongly called eels) preserve the basic features of the ostracoderms. For example, they have no true jaws of the complex type presently to be described, and their gills are pouch-like. Also they have a large elastic rod along the back, known as the notochord, which all backboned animals possess before birth but discard for the more rigid and serviceable backbone. Therefore, though the lampreys are millions of years removed from Grandfather Fish, they are classed with him and the ostracoderms, under the superclass Agnatha (jawless).

Grandfather Fish seems to have fed on small living things, probably by sucking them into the mouth slit by a pumping action of the throat. But his descendants, the lampreys and hagfishes, attack other fishes, hanging on by a horny sucker that is armed with sharp thorns, and rasping the flesh of their victims with their thorn-studded tongue.

While the earlier ostracoderms fed on small creatures or floating organic particles, all their principal descendants later attained a predatory or robber stage. Some never got further, others pushed on to become quiet vegetarians. Jaws, it may be noted, were primarily organs for seizing and biting living prey, and all the backboned animals above the ostracoderms and lampreys are frequently grouped together into a superclass called "gnathostomes," or jaw-bearing vertebrates. In spite of this classification, at least some ostracoderms (for example, Pteraspis) had a jaw-like bone in the lower margin of the mouth and a firm palate against which it could work.

In these shell-skinned ostracoderms the head and forward part of the body were usually covered with a shelly case. How did this condition come about? The physiologist Homer Smith has put forward an ingenious and highly plausible theory, as follows. When the still more remote and as yet undiscovered vertebrates came up out of the sea into the rivers and lakes, their blood, or body fluid, which was nearly as salty as the ocean itself, would tend to absorb the fresh water through the then naked or porous skin. Since fresh water tends to pass through a permeable membrane at a greater pressure than that of the saline blood, the fresh water would continue to be absorbed until a state of dropsical swelling would result. The proper balance for the animal was restored when its kidney tubules began to secrete an excess of calcium salts. These, being carried by the blood stream and deposited in the skin, eventually formed a waterproof armor of surface plates. Hence the building up of bumps and spikes on the surface plates, formerly regarded as a fatal specialization, seems to have been merely a stage in the evolution

Continued on page 163

The Chart

GRANDFATHER FISH AND HIS DESCENDANTS

The following is a detailed explanation of the most important groups of animals shown on the chart on the next spread. This chart outlines the evolutionary road from fish to man, as developed by Dr. William K. Gregory.

Since the period covered is about 400 million years, only the most significant steps can obviously be shown. During this long period, whole groups of animals died out without leaving any descendants to carry on their line. Other large divisions, on the other hand, continued in greater or less abundance to give us the estimated 50,000 different species of backboned animals that we have on earth today.

The chart will be found useful also in connection with succeeding chapters on the history of animal life in North America that are to appear in NATURAL HISTORY Magazine.

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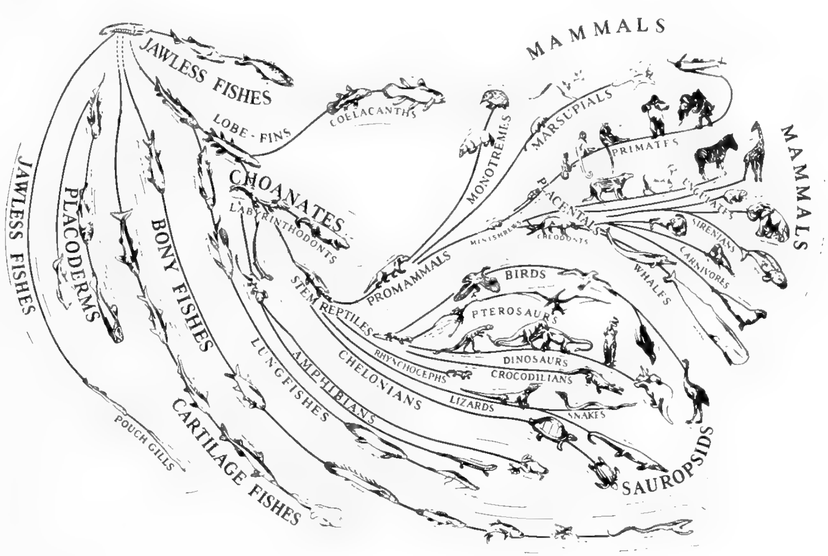

JAWLESS FISHES (Agnatha). These are the oldest and most primitive known chordates, or animals with a notochord or core of the backbone. The group includes the ostracoderms (shell skins) of the Silurian and Devonian ages and their pouch-gilled modern descendants, the lampreys and hagfishes. The casts of the internal structure of the head of ostracoderms reveal paired organs for smelling, seeing, and balancing. These collectively are included in the "basic patents" for the control system of all higher vertebrates, including man. The ostracoderms, although diversified in body, also show the beginnings of median and paired fins, and their motor units, as in higher vertebrates, are the red muscle fibers.

PLACODERMS. This large group was basally intermediate between the "jawless" and the "jawed" vertebrates. It showed an early stage in the formation of complex "gill-arch jaws" plus tooth-bearing jaw plates. The higher placoderms included the curious "joint-necks," an extinct group, mainly gigantic predators.

CARTILAGE FISHES. Sharks, rays, and their fossil relatives and ancestors are included in this group. Its members are generally primitive in their jaws, teeth, and internal organs, but the gristly state of their skeleton is now believed to be due to the retention in the adult of an embryonic condition. The sharks possess greatly developed smelling organs, while in the bony fishes *(see below)* the sense of vision is predominant.

BONY FISHES. These in the broader sense include the vast majority of still existing fishes. In the earlier forms, called ganoids, the massive scales had a thick bony base and were covered with a shiny layer of ganoin. In the modernized bony fishes, or teleosts, the scales have lost the bony plate and the ganoin, and have become thin and horny. The teleosts display the utmost diversity in body form, fins, jaws, teeth, food, and breeding habits. They are very far removed in structure and in time from the stock which gave rise to the land-living vertebrates.

CHOANATES. These include the air-breathing fishes with internal nostrils, including the lungfishes, the lobe-fins, and the ancestors of all the four-footed land-living animals, scientifically known as tetrapods. The chief divisions are:

Lungfishes. These form a side branch appearing in the Devonian and continuing up through all the ages into the existing Australian, African, and South American lungfishes. On the roof of the mouth they have a pair of dental grinding plates like two fans arranged back to back, which work against similar plates on the inner sides of the lower jaw. Their paired paddles are elongate, leaf-shaped to thread-like.

Lobe-fins (Crossopts, Rhipidists). These are the central stock of the air-breathing fishes. They have strong dagger-like cutting teeth fixed to the jaws with greatly infolded (labyrinthine) bases. The group is characterized by paired paddles which are strong and fan-like but have a tapering jointed axis.

Labyrinthodonts. These are the first of the four-footed land animals (tetrapods). Their teeth are infolded at the base as in the lobe-fins, and the skull also is similar, though it lacks the opercular bones covering the gill chamber. The paired appendages, however, have become typically five-rayed, essentially as in all higher vertebrates. The shoulder girdle is not tied to the skull. The pelvis is subdivided into three bones on each side.

Amphibians (modern). In this group are the salamanders, newts, sirens, frogs, toads, and the worm-like caecilians. Their young are hatched from eggs spawned in the water or developed in a watery medium enclosed in a leafy covering. The "tadpoles" usually have fish-like gill arches and external gills. During metamorphosis, legs sprout from within the body, and the adult animal may become either fully land-living or secondarily water-living.

SAUROPSIDS. This vast assemblage includes all the diverse reptilian hosts, together with the birds. The extinct stem reptiles (cotylosaurs) grade back almost

GRANDFATHER FISH and his descendants

By WILLIAM K. GREGORY
Curator, Departments of Fishes and Comparative Anatomy, The American Museum of Natural History

This chart shows 81 of the mo million-year road from fish to yet published because it embod because it groups the animals i steps rather than other details that the main divisions are in descending siz

‡ *Animals thus marked are extinct.*

Drawings by H. ZISKA *and* JOHN C. GERMANN

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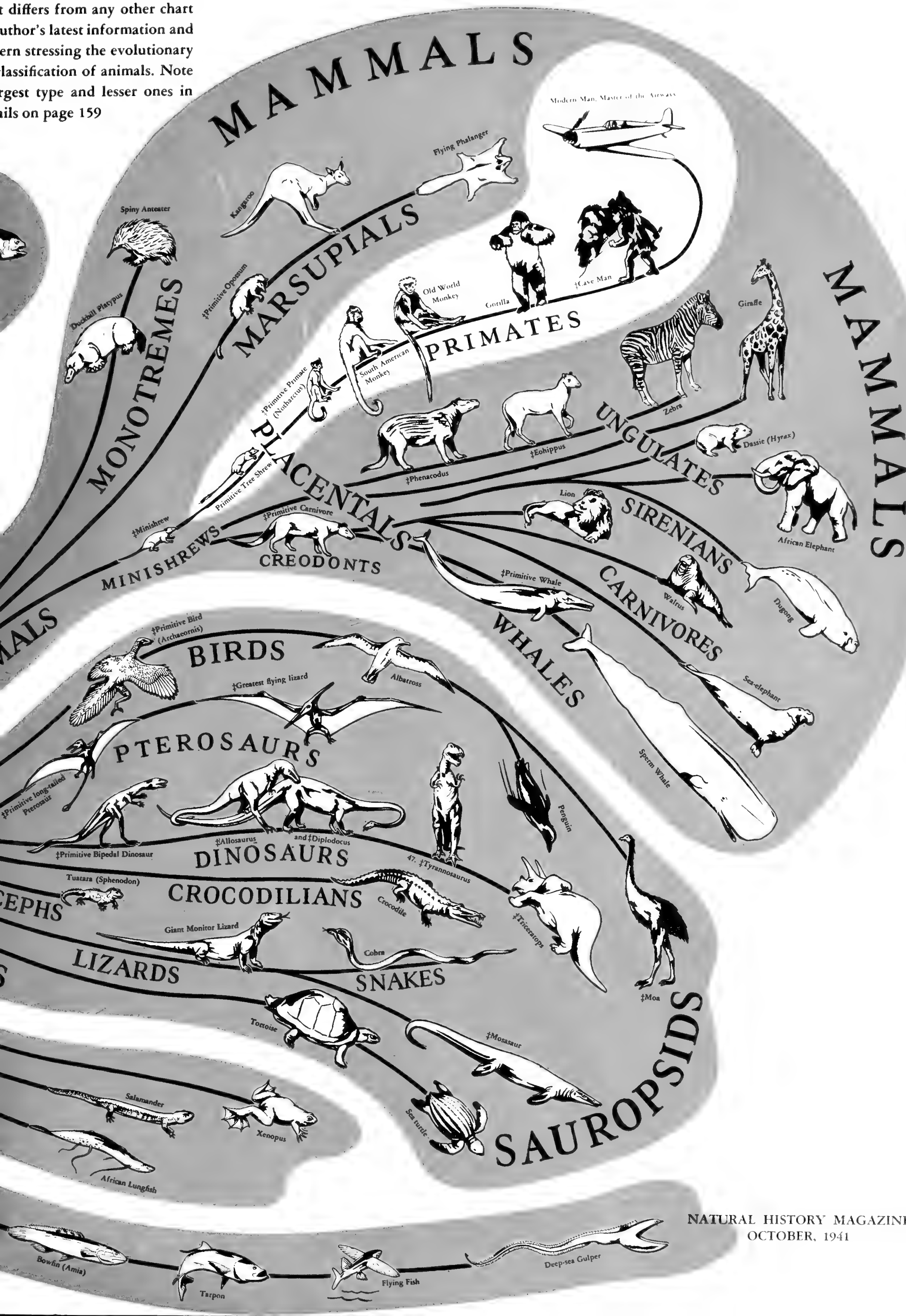


into the labyrinthodonts and forward toward the more typical saurians. In general the reptiles represent a further advance beyond the labyrinthodonts. They have succeeded in reducing or eliminating the fish-like or tadpole stage, and the eggs may be buried in the sand or hatched within the body of the parent. Devices for maintaining a more stable body temperature to resist severe changes are at best but poorly developed in the lower reptiles.

The main divisions of this group are as follows:

Chelonians. These are the turtles and their allies. They are the oldest branch of the stem reptiles. They have performed the amazing anatomical feat of developing a rigid dermal outer skeleton and at the same time drawing the top of their shoulder girdle well beneath the projecting rim of the first ribs. In the sea turtles the large forefeet have been changed into wing-like paddles.

Lizards. Though not far removed from the stem reptiles, the lizards have developed a skull in which the surface bones, especially those that originally covered the jaw muscles, have dwindled into narrow strips and bars.

Snakes. These are essentially lizards that have lost their limbs and acquired huge, loosely attached jaws for swallowing large prey. The extinct marine lizards (mosasaurs) were closely related to the existing monitors.

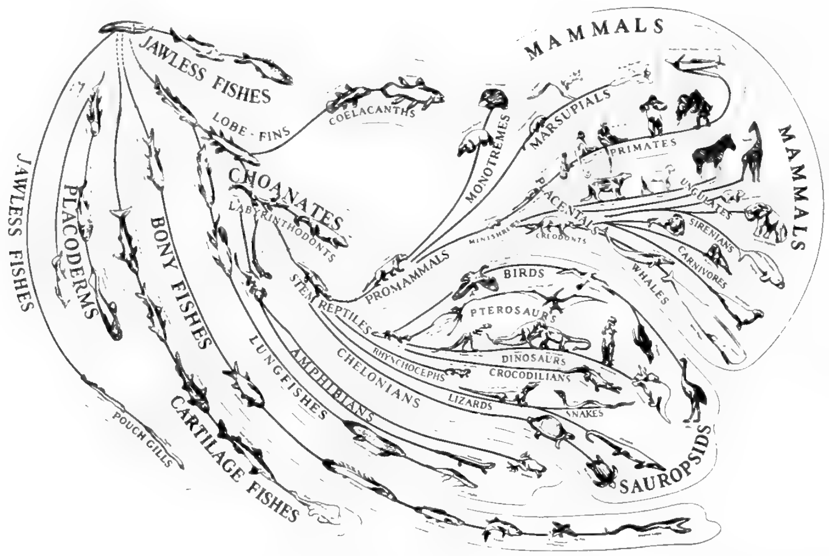
Rhynchocephs. These are represented today only by the tuatara of New Zealand. They were an early side branch equipped with somewhat rat-like front teeth, and are related to the lizards on one hand and to the stem of the dinosaurs on the other.

Thecodonts. These were slender fast-running, lizard-like reptiles of the Age of Reptiles, with many skeletal features that foreshadowed the ancestors of the crocodilians, dinosaurs, and other extinct groups.

Crocodilians. Now reduced to a few survivors (crocodiles, alligators, gavials), these were once a highly diversified group. They were an aquatic side branch from the ancient forebears of the dinosaurs. Many features of the skeleton are like those of dinosaurs, but others are highly peculiar. Their skull and jaws form an exceedingly efficient springtrap for capturing fish and even large mammals.

Pterosaurs, or flying reptiles. In these animals the enormously enlarged fourth finger of each hand served as a movable framework for a wing membrane. These reptiles, although excessively specialized, were a side branch of the thecodont group mentioned earlier.

Birds. These are truly "glorified reptiles." The strong, greatly improved four-chambered heart and the presence of feathers and air sacs enables a high body temperature to be developed and maintained within wide limits.



PROMAMMALS, or mammal-like reptiles. The earliest of this series were small, lizard-like offshoots of the stem reptiles; but as we follow the history of the group, many of them became swift-running creatures, and some gradually approached the earlier mammals in the details of their skeleton. For example, the teeth in *Cynognathus* and related forms became differentiated into incisors, canines, premolars, and molars—all adapted for a flesh-eating diet and thus foreshadowing the central group of mammals. At the rear end of the skull the joint with the first or atlas vertebra of the neck was formed by a double ball-and-socket, as in the mammals. A bony palate of mammalian type was being formed, and the limb bones were becoming fitted for swift running.

MAMMALS. In general the mammals are characterized not so much by the fact that they "bring forth their young alive" (because certain sharks, lizards, snakes, and ichthyosaurs also follow this method), but because the newborn are fed with milk from the mother's breast. Among the mammals are the following:

Monotremes. These interesting animals (including the duckbill platypus and the spiny anteater) differ from other mammals in that their eggs are not developed into young inside the body of the parent but are laid, like those of reptiles. Also the breasts are represented only by milk-secreting depressions on the ventral surface of the body. But the skin is well provided with hair, as in mammals. The popular statement that the duckbill is a link between birds and mammals is entirely in error.

Although the oldest known mammals date from the upper Triassic period (about 165 million years ago), fossil remains of this group are for the most part exceedingly rare during the greater part of the Age of Reptiles. The most conspicuous examples are the numerous and diverse fossil jaws of very small mammals, ranging from the size of those of a mouse to those of a kitten, which have been found in rocks of the Jurassic period, near Oxford, England and in Wyoming, United States.

Marsupials. Near the close of the Reign of the Dinosaurs, another glimpse of early mammalian history is afforded by discovery of a lower jaw and parts of a skull associated with the bones of a dinosaur. These represent a primitive opossum, the forerunner of the great marsupial division of the mammals, in which the young are born in a very immature condition and are subsequently nursed in the mother's pouch.

Placentals. All the higher mammals, including carnivores, herbivores, primates, and whales, belong to this division, in which the unborn young float in the interior of a membranous bag. A part of the bag, called the placenta, is in contact with the inner wall of the mother's womb. Although the blood of the mother does not pass directly through the placenta, this absorbent organ is able both to select from the mother's blood nutritive material for the growing fetus and to excrete waste products from the latter into the maternal blood stream. Partly by means of this improved method of producing high-grade young, the placentals have become the dominant group of mammals in the present epoch of earth history.

The oldest known placentals are represented by a few very small fossil skulls and jaws found in the Upper Cretaceous rocks of Mongolia. Among these are some whose teeth, jaws, and skull appear to embody the fundamental features for the rise of all the diversified insectivores, carnivores, and derived groups of the Age of Mammals.

of the outer or dermal skeleton. And, especially among the later or true fishes, there is much evidence that teeth arose from little swellings or spikes on the surface plates of the mouth and gill region.

To make effective use of its jaws and teeth, an animal must usually be able to pursue its prey. Hence all predators, at least of the vertebrate type, have a complicated system of locomotor organs, the power of which is furnished by the red muscle fibers. The beginning of contractile tissue is suggested in the jellyfishes, in which the mouth and body wall already exhibit sensitivity and contractility, which are the basis of the nerve-muscle complex. But by the time of the ostracoderms the vertebrate stock had already reached the stage in which the muscle fibers were strung in parallel series along the sides of the body. These were separated by partitions into more or less **W**- or **V**-shaped strips, called myomeres. A long series of these muscular segments was arranged on each side of the elastic notochord. But the real secret of vertebrate locomotion is found in the crossing over of certain nerve fibers from one side of the spinal cord to the other. This arrangement starts a wave of contraction that runs down along one side of the body, while almost immediately afterward another wave is started on the opposite side. In this way, the primitive vertebrate, although by no means flag-like in shape, could "wave" its way along the bottom or weave through mud, and was eventually able to swim freely in pursuit or flight.

The ostracoderms when we first find them had already attained a considerable diversity of body form, as shown in the accompanying illustrations. Broadly speaking, the most primitive form was shaped somewhat like a flattened raindrop, while one or more specialized side branches were much flattened, like a skate, and another was narrow and tending to be ribbon-like *(Pterolepis)*. In the typical cephalaspid ostracoderms the head shield was almost semicircular in outline, domed toward the center. The eyes were on top and looked like a pair of spectacles. Presumably these creatures clung to the surface of rocks or moved slowly along on the bottom. In *Birkenia,* which appears to be related to the cephalaspid stock, the body was becoming quite fish-like with the small head streamlined into it.

The interior of the head of the more primitive ostracoderms was comparatively simple in plan. There were three right and left pairs of organs for smell, sight, and the balancing sense, arranged one behind another on each side of the middle. Between them was the brain, doubtless showing corresponding subdivisions, and behind them the medulla and spinal cord. Below the brain and main sense organs was the roof of the chamber into which the mouth and gills opened. Thus we see that this lowly ostracoderm had already achieved the general pattern and arrangement of a number of important organs that have been retained in all later backboned animals, including man.

When some of the ostracoderms died, the mud seeped into the blood vessels of the head shield and followed the tunnels in the skeletal tissue left by the cranial nerves. Thus when the entire mass was turned into rock, there was a permanent record of the blood vessels and nerve tunnels. Stensiö found that he could safely identify most of these vessels and nerves by careful comparisons with the similar parts in the existing lampreys.

As already mentioned, the initial step toward the development of complex jaws had been taken by Grandfather Fish, himself, who was already using some of the upper and lower plates around the mouth as tweezers or pincers. The next great advance is seen in the Devonian period (about 300 million years ago), when certain fishes (placoderms) began to enlarge the first of the internal skeletal hoops supporting their gills, as bases for the surface jaw plates.

From the placoderm stock the foregoing "basic patent" for complex jaws was transmitted with increasing modification in detail to the cartilage fishes, bony fishes, lungfishes, stem amphibians, and higher vertebrates. Unmistakable remnants of this arrangement may be seen in the jaws and throat of the embryos of existing fishes and higher vertebrates, including man.

The ostracoderms and placoderms also show very significant experiments in the formation of paired locomotor appendages. Even in some of the ostracoderms the sides of the body just behind the head shield were prolonged into rounded lobes or projections of the body wall, which presumably were more or less movable and served somewhat like the lateral stabilizers of an airplane. When, as noted above, the kidneys secreted an excess of mineral matter, it often accumulated on the surface in the form of spikes located along the back or on the sides of the body. Behind the spikes the skin was pulled up into a sort of fin or web. These backwardly curved spikes, like the other projections, served as stabilizers in keeping the fish on its course.

Later the **W**- or **V**-shaped muscle segments of the body began to attach themselves to the underside of the spikes and fin webs. From this it was but a short step to a stage in which the spikes could be raised or lowered, thus greatly improving the fish's ability to make quick turns. This took place in a group of placoderm fishes known as the acanthodians. The earliest ones retained widely based spikes, but

in later acanthodians the spikes became more and more slender, and the body elongated.

As we follow these early fishes along their predatory career, we see improvement in their machinery for attack. Thus we come to the Devonian "joint-necks," scientifically known as arthrodires. They receive their name from a useful horizontal peg-and-socket joint on either side between the head shield and the shoulder plates. When they were about to attack their prey, they raised the head and opened the mouth very wide. The front "teeth" on the larger arthrodires were somewhat like a parrot's beak. Behind the beak were shearing plates, like butcher's knives. Dr. Bashford Dean, the American Museum's first Curator of Ichthyology, with a humorous touch of understatement, said that the arthrodires were "doubtless unpleasant neighbors," especially to the fin-fold sharks (Cladoselache), which he himself made famous in zoology textbooks.

Thus most of Grandfather Fish's early relatives had the advantage of some sort of armor. As they became more formidably equipped with offensive weapons, however, and developed the ability to move rapidly, this armor was for the most part reduced or eliminated.

The story of the rise and diversification of the swarming lines of bony fishes (ganoids and teleosts) is demonstrated by thousands of fossil and recent forms. But here we must be content to say that the earliest bony fishes had bodies completely encased in an armor of thick scales with a bony under layer and a shiny surface of enamel (whence our name ganoid for these fishes, from the Greek *ganos*, shiny). The horny scales of modernized fishes are a later development.

Grandfather Fish might envy the jaws and feeding habits of the bony fishes that descended from him, because they became exceedingly diversified. From a primitive stage in which the upper jaw was fixed, one can trace the changes into highly protrusile sucking jaws, jaws armed with sharp-edged sabers, massive jaws with crushing teeth, tube-like jaws with little nippers at the tip, etc. It is hardly necessary to state that the modern fishes as a whole have become very far removed from the earlier lines that gave rise to those backboned animals which established themselves on land.

The modern sharks used to be regarded as paragons of primitiveness, but it is now coming to be realized that the gristly or cartilaginous base of their skeletons may instead be only a hold-over of a normally embryonic feature into the adult stages of life. In the cartilage fishes the pectoral fins range from slightly movable, wide-based keel fins acting as elevators and depressors in swimming, to flexible paddles with a narrow wrist-like base. As the muscles in the fin bud grew upward and subdivided into a fan-like cluster, so did the bony rods that supported them. Thus were produced large fan-like fins as in the skates, in which the individual rods could be moved in sequence like the keys of a piano.

As long as fish remained fish, their opportunities for invading the land were quite limited; and only a few forms of present-day fishes venture to risk the traditional fate of a "fish out of water." This undertaking was successfully achieved some 300 million years ago, however, in one of the most dramatic and far-reaching events in the whole history of life. The modern fishes which temporarily manage to live on land include the famous mudskipper, the tree-climb-

PROTECTION is afforded our surviving ganoid fishes, like those of the past, by their hard, enamel scales *(below)*. Most modern fishes, on developing offensive weapons and rapid movement, adopted more delicate ones. This is the famous *Polypterus* of Africa

AMNH photo

ing fish *(Anabas),* and certain eels and eel-like fishes. Suffocation in air has been avoided either by developing an accessory enclosed gill chamber with a supply of oxygenated water, as in the labyrinth fishes, or by the further development of the lungs. These were the birthright alike of the lungfishes and the lobe-fins.

The early lungfishes were well equipped to burrow in mud and thus survive seasonal droughts, as their descendants still do in central Africa. But they never developed strong limb-like paddles, and in the later lungfishes the paddles have been reduced to long threads. In our search for the forerunner of the first land animals, the evidence leads up to the air-breathing lobe-fins; for they alone have the right combination of characteristics to give rise to the severally distinctive patterns of skull and skeleton found in the earliest amphibians.

We are speaking of very remote time, but even so, we of today have a link with that distant era before the backboned animals came out onto the land. A very specialized side branch from the lobe-fins were the coelacanths. The last of the coelacanths, it was formerly thought, perished with the dinosaurs at the close of the Cretaceous period. But in 1938 some fishermen who were trawling off East London, South Africa, hauled in a strange-looking five-foot fish. After careful study by Dr. J. L. B. Smith, this was proved to be the only known living descendant of the coelacanths.*

The oldest lobe-fins of the mid-Devonian had pectoral fins of the fringe-finned (crossopt) type with a jointed axis and delicate side rods; but the more advanced Upper Devonian fish known as *Eusthenopteron* had broad, spreading pectoral fins, supported by a strong skeleton *(see drawing).*

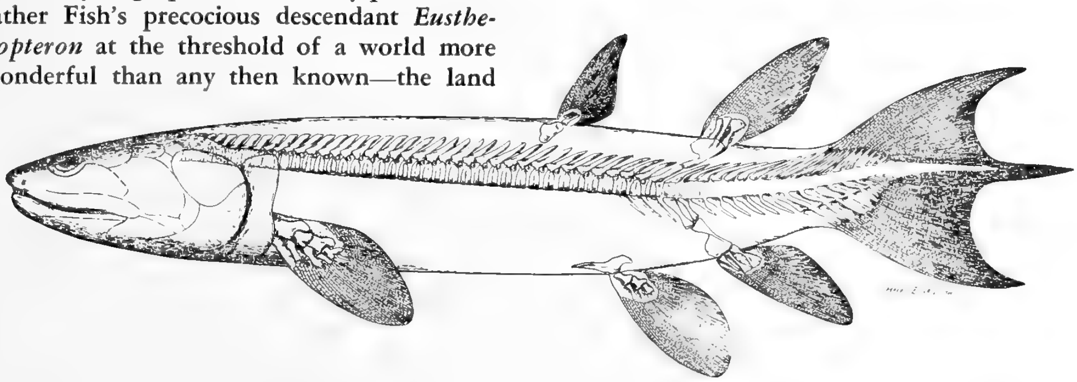
But exactly *how,* the reader may well ask, were the flexible paddles of the air-breathing lobe-fins able to bear the weight of the body on land, which eventually became perhaps their foremost duty? After several years' study of the fossil and anatomical evidence, my colleague, Henry C. Raven and I have ventured to put forward the following partly new theory. As the paddle became bent at the future elbow and wrist joints, its bones gave rise directly to the three arm bones—humerus, radius, and ulna—and to the central carpal bones of the hand. The bones corresponding to the ones farther out on our hands, on the contrary, seem to have come from new buds from the rear border of the original paddle bones, as indicated in the individual development of the living newts and salamanders. The horny rays of the fin must have diminished and finally disappeared, as they did in the lungfishes. Meanwhile the muscular lobe of the paddle grew outward and subdivided into the muscles of the hand. The rear paddle became modified in much the same way.

Thus *Eusthenopteron* stood almost at the threshold of a far greater and more diverse world than any that he or any other water creature had ever known. For when his descendants began to push their frog-like snouts up on to the river banks, our ancestors were taking the initial step toward the conquest of all the lands.

[*The epic story of the rise and evolution of our four-footed, land-living animals will be told in successive issues of* NATURAL HISTORY.—ED.]

*See Edwin H. Colbert, *"A Fossil Comes to Life,"* NATURAL HISTORY, *May, 1939, p. 280.*

PADDLE-LIKE FINS for "walking" on mud and the ability to gulp air occasionally put Grandfather Fish's precocious descendant *Eusthenopteron* at the threshold of a world more wonderful than any then known—the land



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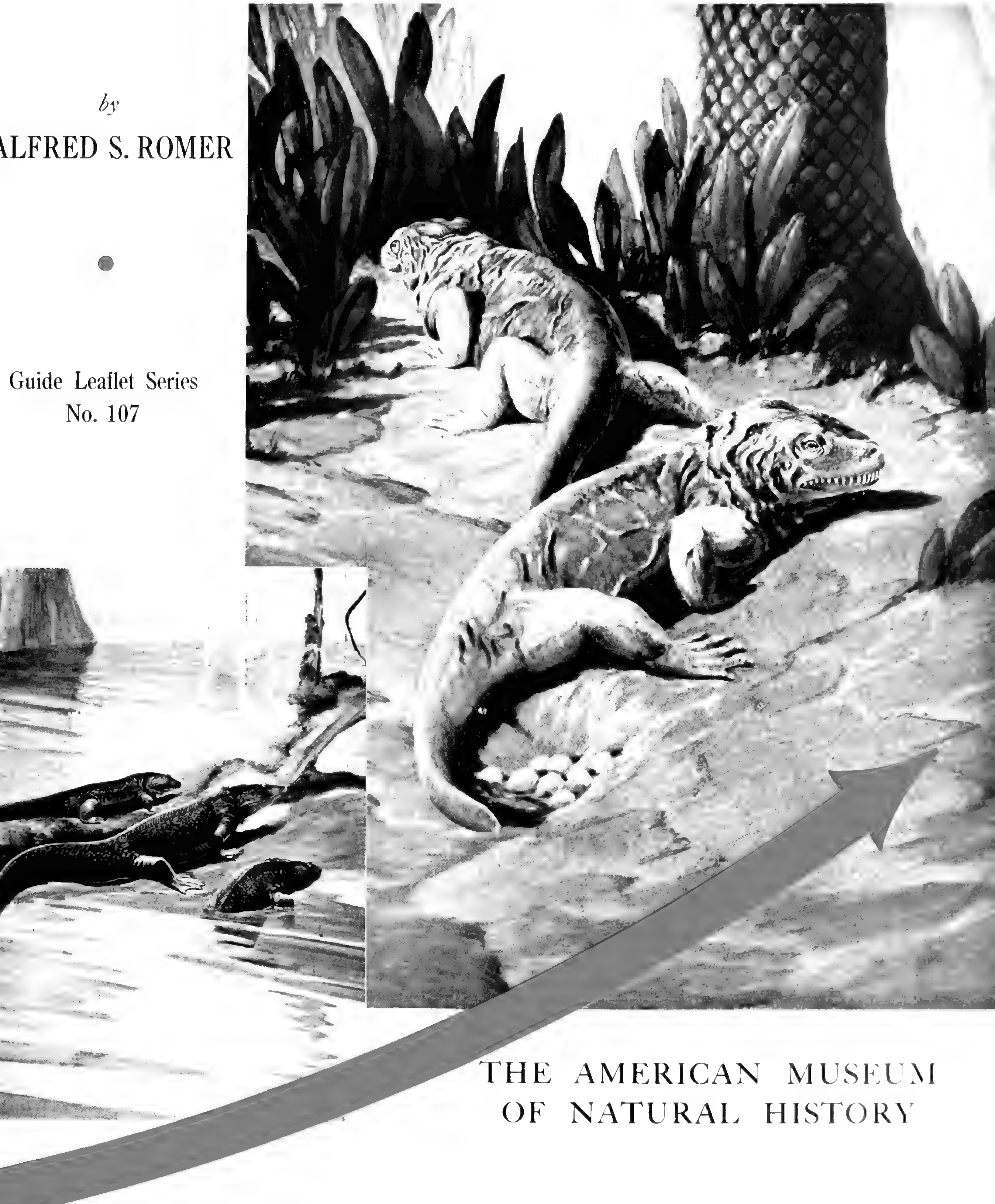

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The first *Land* Anim

By ALFRED S. ROMER*

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Life had existed in the water for many millions of years before the first backboned animals ventured on land. What lured them to take this epoch-making step? Better food, more air, or greater safety might seem the answer. But the true reason is as astonishing as the fact that the "accident" of their adventure populated the land with the 30,000 species of animals we know today

FISHES are all very well in their way. As Doctor Gregory pointed out in last month's NATURAL HISTORY, we owe much to these lowly relatives of ours. In them were developed the basic bodily patterns that have made the backboned animals, or vertebrates, dominant among animal types; and in the course of the ages fishes have evolved into a vast array of types which successfully carry on almost every mode of life available for water dwellers.

But this is only the beginning of the story. Above the primitive fish lay other and greater opportunities for the vertebrates. Beyond the banks of streams and lakes where our early ancestors swam, lay the land. Plants had already emerged from the water in ancient days to clothe the earth, and primitive insects and a few other lowly animals had also come ashore. The vertebrates were not slow to follow. From the fish stage there developed four-legged land dwellers which, stage by stage, gradually conquered the surface of the earth.

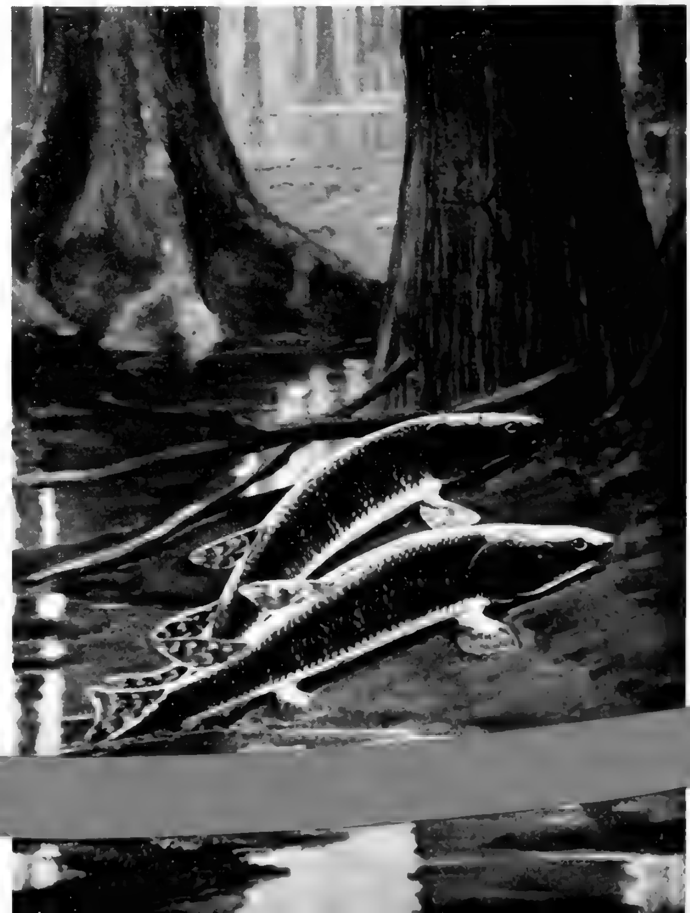
The general nature of the steps, and the evolutionary position of the animal types which were affected were shown in the chart accompanying the preceding article in this series. From the lobe-finned fishes as ancestors there developed the amphibians, inconspicuous today but of vital importance in early times as the first vertebrates to set foot on land. From early amphibians, with the development of a shelled egg capable of being laid on land, came the first reptiles, which had definitely left all traces of a water-dwelling stage behind. Once these first reptiles were firmly established there began a great wave of evolutionary

*Doctor Romer is one of the world's leading authorities on the first land animals. He has collected, studied, and described many of them, and has toured America and Europe in this line of scientific investigation. He has for many years explored the Texas Redbeds, where this chapter in the early life of our continent has its setting.—ED.

TIMETABLE OF THE AGES

Eras	Periods	Estimated time since beginning of period (in millions of Years)	Important events
CENOZOIC (Age of Mammals)	Quaternary	1	Man
	Tertiary	60	Rise of mammals
MESOZOIC (Age of Reptiles)	Cretaceous	120	Extinction of great reptiles
	Jurassic	155	First birds
	Triassic	200	First mammals; Reptiles differentiate and dominate
PALEOZOIC (Age of Ancient Life)	Permian	225	REDBEDS
	Carboniferous	2[illegible]	Amphibians abundant; first reptiles; First amphibians
	Devonian	340	Fishes abundant
	Silurian	375	
	Ordovician	450	First traces of vertebrates
	Cambrian	550 ↓	Lower animal types abundant, no vertebrates

What happened when fishes first came out on land is vividly revealed in the Redbeds of Texas. These rocks contain the remains of many transitional animals—hang-overs from earlier days and forms hinting of things to come



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Drawings by Francis Lee Jaques

3 Conquest of the land was assured when archaic reptiles like *Seymouria (above)* stepped ahead of their amphibian ancestors. This animal lived in what is now Texas

1 *(Left)* The first use of fins as limbs is seen in this lobe-finned fish of about 300 million years ago. Both pairs of fins have developed into strong paddles. This is *Eusthenopteron,* whose backward cousins were still living when the Redbeds were formed

2 The fins have become five-toed hands and feet. This primitive amphibian was probably well able to breathe air but had to return to water to lay its soft eggs. *Cricotus,* described in the article, closely resembled this animal, *Diplovertebron*

development which resulted in the appearance of the dinosaurs and other spectacular creatures of the Age of Reptiles. And eventually the characteristic birds and mammals of more modern times emerged.

The development of these more advanced types will form the theme of later articles in this series. Here we shall stick to fundamentals. We shall examine some of the early four-footed animals and try to find how and why and in what guise they accomplished that most dramatic step—emergence from the water to the conquest of the land.

For undertaking such an inquiry no better opportunity is afforded than in the early land fossils found in the 250-million-year-old Redbeds of western Texas.

Archer, Baylor, Wichita, Willbarger are the counties whence come the Redbeds fossils; Wichita Falls is the local metropolis; Seymour and Archer City smaller towns, which are often headquarters for Redbeds fossil-hunters. It is a land of rolling, brushy prairies, of great herds of cattle, occasional farms, with here and there a cluster of the oil derricks that have brought much prosperity to the region; a land with some unpleasant features—heat and thirst of a summer and an unpleasant abundance of rattlesnakes,—but on the whole a pleasant country to work in, full of the friendliness and hospitality of the Southwest. Here and there on the hillsides are the "breaks" for which the collector searches—places where storm waters have washed the earth bare and exposed beneath the soil the underlying clays, shales, and sandstones, often red in color, where fossils may be found.

Bones were first discovered here in pioneer days, two-thirds of a century ago, by old Jacob Boll, a Swiss botanist then teaching in Dallas. Their importance was realized by Professor Cope of Philadelphia, who immediately employed him to explore the field. Boll gave his life in this quest: he was taken ill and died soon after in his tent on the lonely prairie, with only a frightened boy to tend him in his agony. But others soon followed, and the work of many men over several decades gave us a considerable acquaintance with the life of Texas in early days.

Order of events

In the diagram on page 236 is a simplified geologic "timetable," listing successive eras and periods of the world's history. This shows the place of these Redbeds in the sequence of world events and their strategic importance in the study of the conquest of the land. These deposits were laid down at the close of the Carboniferous period (the period when the greatest coal deposits were formed) and the beginning of the succeeding Permian period which marks the end of the Paleozoic era, the Age of Ancient Life. This part of present-day Texas was then not a high prairie, but a low-lying delta country, apparently subject to occasional droughts, but covered with a rich vegetation. Across this lowland meandered slow streams, which arose in mountains situated in what is today east Texas and which emptied to the west in a great sea. In these streams and on their banks lived animals of many types, showing every stage in the emergence of vertebrates from water onto land.

Thus, in the Redbeds we find, existing at one time, representatives of a whole series of evolutionary stages,—just as in a single city we see buildings in use which represent different periods in the progress of architecture. There were typical lobe-finned fishes of the sort from which the land animals got their start; there were creatures that lived partly in water and partly on land; and there were even early reptiles, which had left the water entirely.

The fish ancestors of land animals were represented in Redbeds times by a form known as *Megalichthys,* "the big fish" (really not very big, only a foot or two in length). Like his other lobe-finned relatives, *Megalichthys* had what it takes to be the ancestor of a land form,—stout fins with muscles and bones, which needed only to develop further to become the typical leg of a land animal, and well-developed lungs for air breathing. By Redbeds times his cousins had already reached the land as amphibians, the class represented today by frogs and toads, newts and salamanders. But *Megalichthys* himself stayed on as a form old-fashioned even in those days, living for the most part a contented existence in his ancestral streams.

Next in evolutionary order among the animals of the Redbeds we see representatives of the earliest type of four-footed creatures. The advance had occurred a number of millions of years before, but an exceedingly archaic representative of the transitional type was present in the amphibian *Cricotus.* This fellow was an animal of fairly good size, ranging from a yard up to five feet or so in length. In general his appearance was somewhat like that of some of the modern salamanders, with a rather long and slender body, a long tail, and four short and feeble legs. But in internal architecture *Cricotus* was quite different from these living amphibians and in many ways exceedingly similar to his lobe-finned ancestors and relatives. Further, while *Cricotus* had developed land limbs, most of his existence appears still to have been spent in the water. He was potentially a land animal; but in reality this ancestral type of amphibian was little more than a four-legged fish.

How did land life begin? Why did amphibians such as *Cristotus* ever leave the water at all? Why did

Heat, thirst, and the danger of rattlesnakes must be reckoned with in the exploration of the famous Redbeds for the earliest land animals, but the region also offers the hospitality and charm that are characteristic of Texas. This land, now dry, was a low-lying delta country with luxuriant vegetation when the ancestors of all our modern land animals struggled to establish themselves

their ancestors ever develop their fins into limbs capable of locomotion on land? Many answers to this problem have been suggested, but most of them are highly unsatisfactory.

"To escape from enemies," some have said. But the ancestral lobe-fins were among the largest and most aggressive fishes in their native puddles.

"To gain new food supplies," say others. But both early amphibians and their fish ancestors were not vegetarians but eaters of animal food, and there was little animal food on land at the time. There were some primitive insects, to be sure, but so slow and clumsy were the legs of the old amphibians that even an archaic cockroach would have had no difficulty in escaping.

"The lure of atmospheric oxygen" is another fine phrase, but it is pure poppycock as an explanation of the emergence of amphibians. For, as we have seen, the ancestral lobe-fin had competent lungs, and he did not need to leave the water to breathe. By simply lifting his nose to the surface of the pond, he would have the world's oxygen supply at his command gratis.

The real answer to the problem of the development of land limbs appears to be a simple one, although seemingly paradoxical: *legs capable of land locomotion were developed to enable their possessors to stay in the water!*

To visualize the situation, let us compare the type of life led by our friend *Cricotus* with that of his relative *Megalichtlhys,* who represented the fish stock from which he had come. Both appear to have led, in Redbeds times, much the same sort of life. The fish spent his life in the water, feeding upon minnow-like fishes found in abundance there. So, too, lived the amphibian *Cricotus.* He had legs but apparently used them only a little. Small fishes too were his diet, and like the fish he was essentially a water dweller. Under most circumstances the fish was as well off as the amphibian,—perhaps even a bit better adapted to an aquatic life, for the dangling legs

of the latter would be an impediment in swimming.

But it appears that hard times knocked at the door even in Paleozoic times, in the form of drought. The geological evidence strongly indicates that in the later periods of the Paleozoic era when all this happened, large regions of the earth were subject to great seasonal droughts. In regions plentifully watered at other times, the streams would be reduced to mere rivulets, deep pools would become foul and stagnant mudholes or even dry up altogether. What then would be the fate of lobe-finned fishes? For a time, and if the drought were not too severe, all might be well enough. They could come to the surface and take in air to make up for the oxygen absent in the water. Even if the pool in which they found themselves dried up completely, they might burrow into the mud and survive for a time.

But what if the drought were really severe, if the water did not return soon? Under these circumstances the immobilized lobe-fins would soon die.

Not so the amphibian. Under such circumstances his newly-developed legs showed their usefulness. *Cricotus* cared nothing for the land,—it was water he sought; and, unlike his finny cousins, he could seek it. Abandoning the dried-up pool and his dying lobe-finned relatives, he could crawl (although slowly and probably painfully) up or down the stream channels or overland; and then, reaching another pool in which water still remained, he could plunge in and resume his normal aquatic life.

Legs were not, we believe, "invented" as an adaptation for land life, but were a happy accident. Originally, it seems, they were merely an adaptation to help the fish-like animals that bore them to survive drought.

Cricotus, then, represents a first stage in amphibian evolution. By Redbeds days other members of the group had branched out greatly and passed far beyond his primitive level toward a true land life. For example, there was *Eryops,* who was a common Redbeds amphibian—a large form, six feet or more in length, powerfully built and having massive, if rather short, legs. *Eryops* may have been to some extent aquatic, but he probably spent much of his life ashore; and other amphibians of his time may have lived almost entirely on land.

Yet chained to the water

Almost entirely, but never completely. And here lies the reason for the eventual failure of the amphibians as land dwellers. The fault lies in their old-fashioned reproductive habits. A fish's eggs are, of course, laid in the water. So, too, are those of typical amphibians. Each year (as today among the frogs and newts) all amphibians must return to the water to lay and fertilize their eggs. The young, as is easy to see in the case of frog tadpoles, pass their early days as purely water animals, using gills for breathing and eating aquatic food. Then comes a violent change, a metamorphosis—the gills shrivel, lungs and legs develop, and many internal organs undergo marked reorganization: the tadpole changes into an adult which can exist on land. But even so, the adaptation to the land can never be complete, for the grown amphibian must be able to return annually to the water for breeding purposes.

This sort of thing is obviously highly inefficient. Suppose, for example, that the reader's car had to be so designed as to be used also as a motorboat. Such a machine can be made, but it would be expensive, inefficient for either line of work, and would probably have difficulty competing with either a proper boat or an ordinary automobile in its proper medium. So with the amphibians. Though able to survive drought conditions such as existed in the early days of the group, they are not remarkably good performers in the water. And the reptiles which arose soon after them are far better adapted for life on land. Faced with keen competition in both environments, the amphibians quite understandably became a "discouraged" group, greatly reduced in numbers, until today they constitute but an insignificant element in vertebrate life. The land they have almost entirely abandoned. At present a few toads range far afield, but most amphibians cling close to the banks, and some salamanders have slumped backward to a state in which they never emerge from the water.

Signs of such degeneracy were present even in Redbeds days, when amphibians were still fairly abundant. An example is *Diplocaulus,* seen at the water's edge in the illustration reproduced on page 243. This grotesque little creature had a broad, flat body and a flat and ponderous head. The limbs were so tiny that they could hardly have lifted the head above the water and surely could not have carried the animal about on land. Such a form was only fitted for a permanently aquatic life, and presumably it spent its days as a mud-grubber in pond bottoms.

The late Sherwood Anderson once entitled a short story "The Triumph of the Egg." This would be a fitting title for the story of the development of the reptiles, which had originated from a progressive amphibian stock shortly before the Redbeds times. In the Redbeds are very primitive stem reptiles (cotylosaurs), best typified by *Seymouria* (named for the county seat of Seymour near which its remains have been found). *Seymouria* was a rather small and stockily built little fellow *(see illustration*

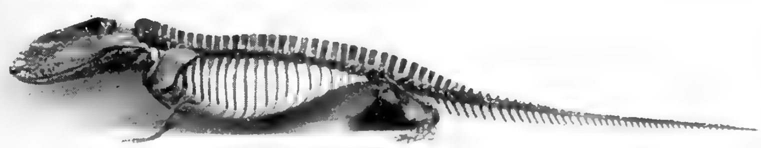
The Oldest Known Egg

THE KEY TO PERMANENT LIFE ON LAND: the earliest and only true egg from the Redbeds. The amphibians, though able to live on land, were obliged to return to water to lay their eggs, which had no shell to protect the delicate embryo within from drying up. This fossilized egg, discovered half a dozen years ago by a keen-eyed collector, Llewellyn Price, epitomizes one of the most dramatic chapters in the conquest of the land. Possessing a protective shell, it represents the basic patent which enabled animals to break the chain tying them to the water. The method of giving birth to living young was a still later development

A PRIMITIVE ANCESTOR OF THE MAMMALS. Certain of the reptiles, like *Ophiacodon* below, led the way in the direction of our vast assemblage of familiar four-footed animals of forest and field

(Below) THE SKELETON of *Ophiacodon,* reconstructed from the preserved bones. Here we have a primitive reptile which, however, had feet and skull that foreshadowed the emergence of mammals, the dominant class of animals inhabiting the earth today

Geo. Nelson photo



From Prehistoric Life, *by P. E. Raymond, Harvard University Press*

on page 237). In his skeleton there are a few features which seem to show that structurally he was a reptile. But he was an exceedingly archaic one, and in many ways quite close to his amphibian ancestors.

The real reasons for the success of the reptiles over the amphibians lie not in the build of the adult body but in the mode of reproduction. The amphibian, as we have seen, is chained to the water. Since the young must develop there, and since the adult must periodically return there for the egg-laying season, the amphibian can never become a purely terrestrial animal. Not so the reptile. For in this group there has been evolved a new type of egg, which can be laid on land. This sort of egg is still laid by turtles and many a lizard and snake today. It is still present in even a few mammals (although most now bear their young alive); and it is found on our breakfast tables in the enlarged form adopted by the reptiles' avian descendants. The egg is protected externally by a shell, which is absent in amphibians. The shell, although firm, is porous; thus oxygen may enter and allow the growing embryo to "breathe." Within the shell a series of liquid-filled membranes gives additional protection to the young and prevents it from drying up. Still further, to supply the food which the encased youngster now cannot gather for itself, much of the egg is composed of a nourishing yolk. So equipped, the tiny germ inside the egg can skip the tadpole stage entirely and grow within its protecting shell and membranes to a point where, on hatching, it can at once take up an existence on land. By the shell-covered egg, the reptile has been emancipated from the water and can now become completely adapted to terrestrial life.

Oldest known egg

We have long felt confident that such a type of egg had been developed by the Redbeds animals that we characterize as reptiles. But fossil eggs are rare, although many a cobblestone in fossil deposits looks like such an object. The first—and only—true egg from these beds was discovered half a dozen years ago by a keen-eyed collector, Llewellyn Price, who immediately recognized its nature and importance. It is a small, oval, iron-stained mass, not at all exciting to look at. But its battered and cracked surface shows tiny patterns of the sort seen on many reptile eggs, and the microscopic structure shows definitely that this surface is an egg shell. This is the oldest known vertebrate egg—approximately twice as old as the famous and more abundant but relatively recent dinosaur eggs from Mongolia *(see photograph page 241).*

Once finally released from the water, there began the spectacular evolutionary development of the reptiles and their descendants. Even in Redbeds times we see the beginnings of this reptilian radiation. And, most interestingly, the commonest reptiles of those early days (pelycosaurs) even showed the beginning of mammal-like tendencies.

The mammals, the warm-blooded, hair-bearing and intelligent animals that include man among their members, are such progressive forms that one might think that they developed late in the history of reptilian life. The reverse is actually true. As will be noted from our geological timetable, the first mammals appeared as early as did the dinosaurs. Advanced, very mammal-like reptiles were present at the beginning of Mesozoic days, and in Redbeds times their ancestors, as pelycosaurs, had already branched off from the main line of orthodox reptilian evolution.

SAILS? A short-lived evolutionary experiment among the early land animals was the development of peculiar extensions of the back among the reptiles known as pelycosaurs. This scene, reconstructed from scientific sources by the well-known artist Charles R. Knight, vividly shows the Texas landscape as it appeared a little over 200 million years ago. Two forms of "sail-carrying" reptiles are illustrated, *Edaphosaurus,* whose spines were shorter and had knobby side-branches, and *Dimetrodon,* whose "sail" was supported on long, smooth spines. Whether these animals went sailing around their prehistoric lakes with these appendages cannot be said. But, as any sailor knows, if they floated with the "sails" projecting above the water, they would most certainly have had to reckon with the wind

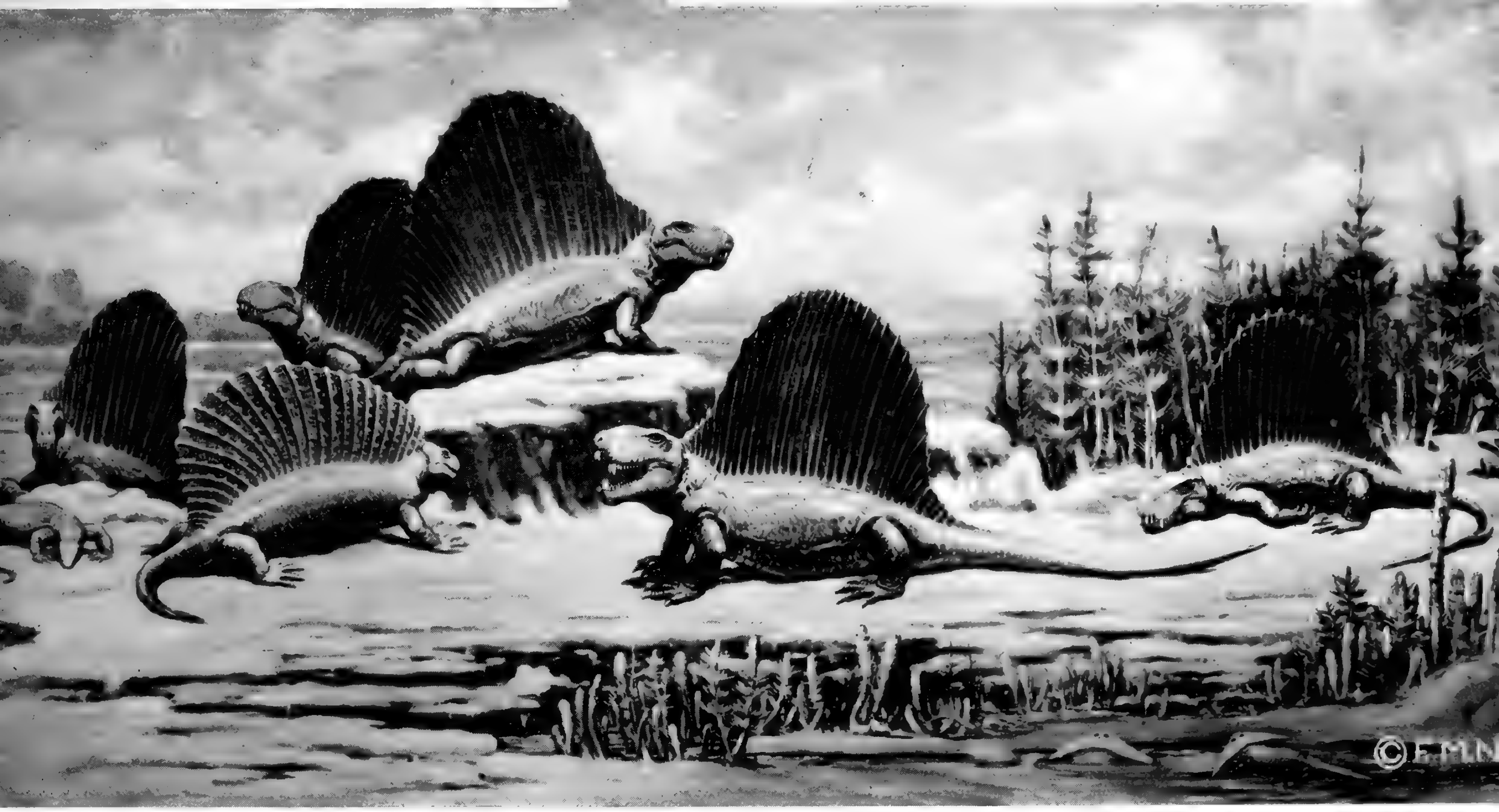
Typical members of these primitive mammal ancestors are such forms as *Ophiacodon (page 241).* This reptile was still very archaic, still very close to the primitive reptile type. He was, however, a bit slimmer, a bit longer-legged, and in details of feet and skull he shows the first faint traces of characteristics which later emerged full-fledged in the mammals.

Evolutionary experiments

No group of animals ever kept solely to an evolutionary main line; always there occur side branches, varied, short-lived "experiments." Among the pely-

The reconstructed skeletons of these "sail-carrying" reptiles are shown below. At extreme left in the painting is a small reptile of the time, named *Casea*. At the water's edge at lower right, the grotesque little amphibian, ***Diplocaulus,*** raises its ponderous head above the water; its limbs were too weak to carry it about on land

Geo. Nelson photos

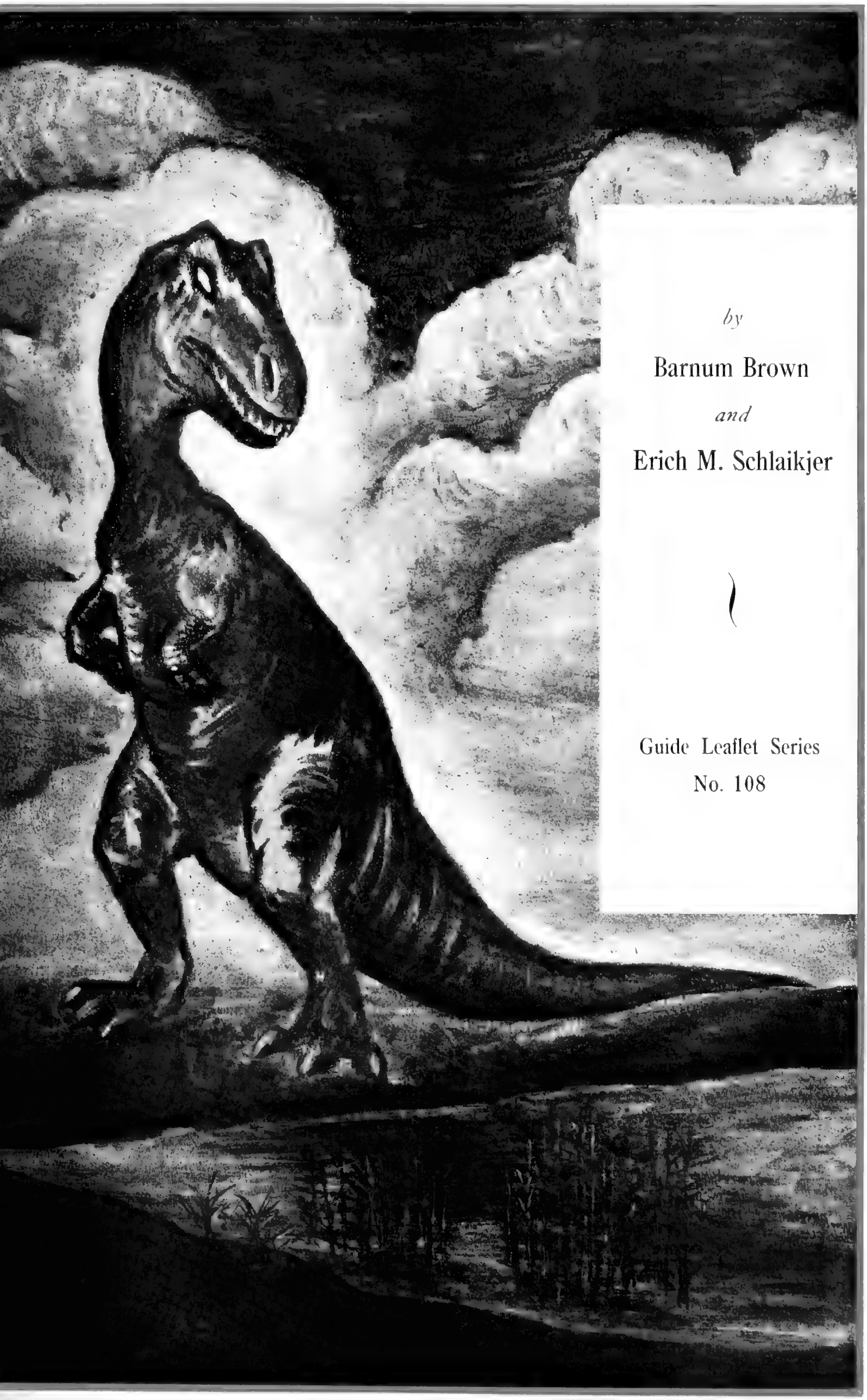


Field Museum photo

cosaurs such development resulted in the appearance of reptiles with peculiar "sails." The bones which cap the back in any ordinary animal grew upward as long spines between which, we believe, there stretched a continuous covering of skin. Two such types are shown in a mural by Charles R. Knight *(see illustration)*. In one *(Dimetrodon)* the spines supporting the "sail" are long but smooth, slender rods; in a second *(Edaphosaurus)* the spines are shorter but with knobby side branches that have been compared with the yardarms of a ship. The purpose, if any, of this peculiar type development is quite unknown. The original describer of these forms suggested facetiously that these reptiles went sailing about the Redbeds lake with them. This idea is not better but also no worse than any other that has been advanced.

Redbeds animals were not as big as those of later days. Although some of them are rather peculiar in build, they lack for the most part the "glamour" of some of their more advanced and spectacular descendants in later geologic periods. My brethren in the bone-hunting game may have their dinosaurs or what not; the writer, at any rate, prefers these older fossils. The study of Redbeds animals is a difficult and tantalizing process. Collecting them is often a dreary task, fraught with heat, thirst, and discouragement. But these ancient fossils are important and their collection well worth the trouble. Land dwellers have progressed far beyond the condition of their crude and ungainly Redbeds ancestors. But the first steps in any process are the most important ones; and, both literally and figuratively, the first steps in land life are revealed to us through the animals of these ancient beds of the Southwest.

THE RISE AND FALL OF THE DINOSAURS



by

Barnum Brown

and

Erich M. Schlaikjer

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THE RISE OF THE Dinosaurs

By ERICH M. SCHLAIKJER

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"Leaping Lena," humble forerunner of creatures that could nibble leaves "four stories" above the ground, gave little promise that her race would rule the earth for 140 million years

At right, **THE 75-FOOT "THUNDER LIZARD," representing the Golden Age of Dinosaurs, looks back 50 million years at a pair of early dinosaurs only a yard long**

Drawing by ALASTAIR BROWN

BIG bones, little bones, all strung together and supported by wires, bolts, screws, and curling pipe—60 or 80 feet of it. Why, it's the biggest thing in the biggest hall in the Museum—yes, in any museum. It's a dinosaur, or "terrible lizard," as the word is usually translated from the Greek.

Even a hundred years ago these ungainly looking things were called dinosaurs. Not all of them, however, are so big or so terrible. This name, though of little scientific standing, is used for the greatest and most diverse group of animals on record. Some were small—no bigger than a jack rabbit and very meek in appearance; others, in fact most, were quite terrible looking. They came into existence 200 million years ago at the beginning of the Mesozoic era, or Age of Reptiles, spread over the whole earth, and then vanished after 140 million years of triumph.

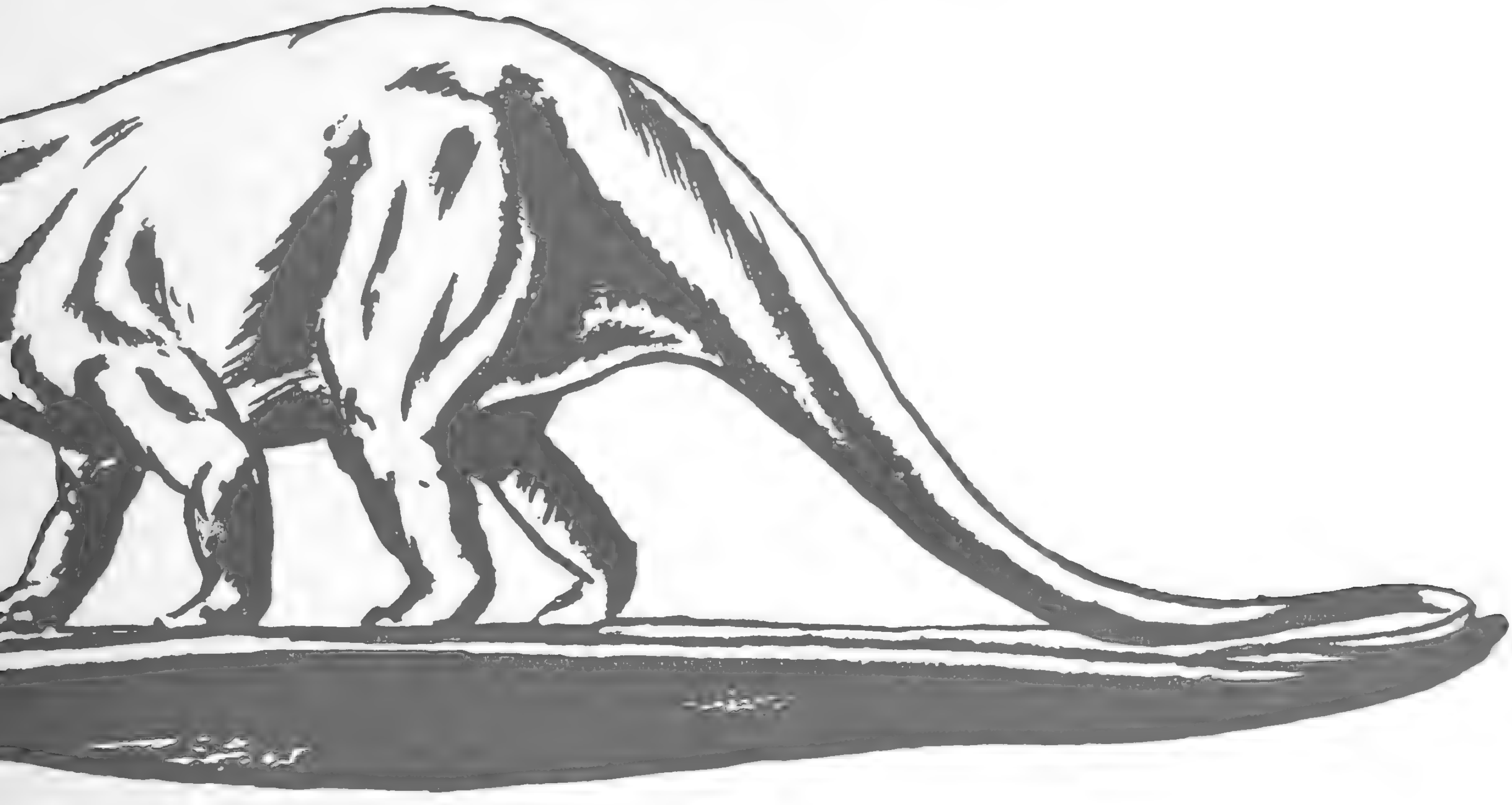
One hundred and forty million years is a long time for any group of animals to rule the world, but the dinosaurs were by far the most abundant and diversified land-living creatures throughout all that time. The life span of any group depends on its ability to cope with the vicissitudes of a changing environment. "Change with me or you die," is environment's command to all life. Because the dinosaurs were plastic they could change, and they evolved into bigger, and so far as they were concerned, better forms. But it was this very demand for change that led them into the inevitable pitfalls of overspecialization, and when the greatest of all climatic changes the reptiles had ever seen came at the close of the era, they could not meet the new demands.

At the beginning of the Age of Reptiles, the earth was still in the grip of one of the most effective revolutionary periods in its history—the so-called Appalachian Revolution. On every continent, mountain building and erosion, with the deposition of vast blankets of debris under semiarid climatic conditions, were the order of the times. In North America, relentless compressional forces had formed a great chain of mountains along the eastern seaboard from Nova Scotia to Alabama, of which our present Appalachians are the mere roots. When these forces gave way, the earth's crust snapped and broke all along the eastern flank of this chain, forming a lofty series of blocks and deep basins. This took place in the early Triassic period—so named because in Europe the extensive rocks laid down during that time are clearly separable into three distinct units.

Throughout the later part of this period, the block mountains were gnawed away by erosion, and the basins gradually became filled with debris—deposits which attained a maximum thickness of more than 20,000 feet. Great sheets of molten rock then forced their way up into these deposits and escaped here and there to form lakes of seething lava. These eventually cooled and were buried under more blankets of fine muds.

By the close of the Triassic, this great interior area, flanked by the high ancestral Appalachians on the west and by less lofty mountains on the east, was a nearly featureless plain. That its climate was arid is revealed by the prevalence of mud cracks, indicative of long periods of drying, also by the "desert red" color of much of the deposits, and by other evidence. There were local areas, however, where the climatic conditions were more acceptable and where life was fairly common. Fishes were abundant in the permanent lakes. And the presence of many fossil ferns, cycads, etc., shows that the humid localities were densely clothed with vegetation.

It was in these more favorable places that tiny,



primitive, crocodile-like reptiles and some of the first dinosaurs lived. Fossil remains of these are extremely rare, but their footprints in the rocks are numerous. It seems strange that so many footprints and so few bones have come to light. Probably the regions most suitable for the reptiles were close to the mountains in higher, cooler, wetter places, which have since been worn away by the elements. From these places, the reptiles wandered over the great inhospitable mud flats, leaving the impressions of their feet "on the sands of time." Only an occasional straggler died by the wayside, and it is his bones that we find.

In western North America the setting was not so uniform. Narrow arms of the sea occupied parts of the Pacific Coast region throughout the period, and in these narrow troughs, thousands of feet of marine sediment were laid down. At times, an arm of the sea would extend inland several hundred miles, as far as western Wyoming or even to western South Dakota. As these retreated, streams from the near-by surrounding mountains followed them carrying mud and silt. Our greatest deposit of such continental material laid down in this period extends from Utah to western Texas and in some localities is over 4000 feet thick. The plants and animals likewise were similar to those then in the east. Also, the fossil logs in the Petrified Forest of Arizona tell us that lofty evergreens clothed the uplands of that time.

Nor was all quiet on the western front of North America in regard to volcanic activity. The whole coastal area was peppered with volcanoes that belched forth clouds of ash. Thousands of feet of erupted material make up most of the Triassic rocks of certain islands on the southwest coast of Canada.

Such were the conditions in the world when the dinosaurs were born. But what are dinosaurs? What was their ancestry?

In size they ranged from twelve inches to 80 feet long—or just about one-third of a city block. In the beginning they all walked on their hind legs, and some kept this method of getting around, becoming more and more highly specialized in it. Others became thoroughly adapted to walking on all fours. Still others did a little of both. The skeletons of some were lightly built and bird-like. These were fleet-footed runners—at first flesh-eaters, later herbivorous. Some of the early flesh-eaters evolved into enormous destroyers of life—the Panzer division of the Age of Reptiles. There were gigantic forms that were at home both on land and in water. Others had horned heads or were heavily armored.

The dinosaurs are indeed so diverse that it is difficult to name features common to all. When we think in terms of an 80-foot *Brontosaurus* or a gigantic *Tyrannosaurus,* what we mean by a dinosaur seems perfectly clear. But some of the first types were almost indistinguishable from some members of another very generalized group of reptiles, the Pseudosuchia ("false crocodiles"), which lived in the same period. The evolutionary change from this group to the dinosaurs was so gradual that it is only in minor details that the two can be separated.

One of these borderline cases had hind legs over twice as long as its front ones. For popular purposes let us call this little animal Leaping Lena, for leap it certainly did, and the diminutive Lena is fitting for an animal that was only a foot long. Its scientific name, *Scleromochlus,* is more difficult to remember. The fossil expert examines the shoulder and hipbones in his effort to tell whether an animal is a dinosaur or not. Leaping Lena had no collarbone (clavicle) or

interclavicle—characteristics of the "false crocodiles" that went before. And its hip joint, though incompletely preserved, seems to have had an opening where the thighbone of the leg hinges—a feature that distinguishes almost all dinosaurs—instead of a closed socket. From what is known, Leaping Lena has about an even chance of claiming the title "dinosaur."

While many of the early dinosaurs resembled one another, the group as a whole can readily be divided into two separate lines, distinguishable by the form of the hipbones. These two groups, or orders, have been named to indicate a comparison with lizards on one hand and birds on the other, Saurischia and Ornithischia respectively. In addition to the hip, various other parts of the skeleton, particularly the jaws, teeth, and skull, show distinguishing features. The point is that the two groups, while they are collectively called "dinosaurs," evolved independently from two different lines of "false crocodiles."

Of the first dinosaurs, the Saurischia, or the ones with the more "lizard-like" hipbones, were the more abundant. Their evolution in the beginning was much more rapid than that of the other group, and by the close of the Triassic period they had evolved into three main lines, which continued down to the very close of the Age of Reptiles. These three main lines may be called the Lightweights, the Meat-eaters, and the Land-and-water dinosaurs. *(See chart, 8 and 9.)*

The first Lightweights (Coelurosauria) are the most primitive dinosaurs known. Their skeletons are very delicately and lightly constructed. They all walked on their hind legs, although in one of the earliest from North America the front legs may have shared some of the weight of the body. Their hind legs, especially the lower part, were conspicuously long and slender. Their skulls were equipped with relatively large eye sockets, and many had small teeth of the type adapted for cutting flesh.

Fox-sized dinosaurs

Various types of Lightweights have been discovered ranging in size from no bigger than a small fox to six or eight feet in length. One which seems to make a good grandparent for all the rest is the little animal named *Saltopus,* which roamed the semiarid plains of what is now Scotland. In life he was no more than three or four feet long. His little skeleton has all the features one would expect to find in the ancestor of the later members of this fleet-footed group of dinosaurs, whose evolutionary development, like that of the Meat-eating dinosaurs, became more and more progressive until near the close of the Age of Reptiles.

The Meat-eaters (Carnosauria) are not so named because they were the only dinosaurs that ate flesh but because as a group they were better designed for a carnivorous life than any other and because their members became the most destructive flesh-eating machines of all times. They were the most efficient Panzer unit ever invented. Some, especially the earliest ones, were quite small, but others attained a height of over 20 feet. There is some difficulty in separating some of their earlier members from the Lightweights.

The Meat-eaters all walked on their hind legs, and their front legs were very much smaller, becoming in the later more specialized forms nothing more than meat-hooks. Their grasping hind feet were bird-like. All had big heads with large, dagger-like teeth, the edges of which were serrated, or saw-like. The largest teeth on the side of the mouth were always towards the front.

True Meat-eaters are known to have lived in what is now South Africa and North America, and though not especially abundant, were well established. The one called *Paleosaurus* ("ancient lizard"), which lived in the Old World, seems to have been very near the starting point of all the later forms. This beast was about ten feet long and was already adapted for walking on his hind legs. His skull was deep, his teeth were specialized for cutting, and his hands were of the grabbing type, with large curved claws on the ends of the thumb and the next two fingers.

The most abundant dinosaurs in Triassic times, were the forerunners of the third group, the Land-and-water forms. They were very widely distributed over the world, having been found in North America, the British Isles, Europe, and southern Africa.

Grandfather of the giants

They were small to medium-sized dinosaurs which usually walked on their hind legs, although some spent part of the time on all four. They had long necks and small heads, and their small, pointed or spatulate teeth were still best adapted for eating small reptiles, fish, or soft-shelled invertebrates. Some may also have been partially herbivorous. An eight-foot creature called *Thecodontosaurus* is the earliest known form and is also the most primitive. That is why he makes a good ancestor for all the rest, and for the later giant sauropods. By the close of the Triassic some had become specialized and had departed from the trail of evolution leading to the later giants. *Plateosaurus* ("oar lizard") is one of these—a clumsy animal that got to be 20 feet long. He is known from a number of fine skeletons which were preserved when the animals died in desert regions of prehistoric France and Germany and were covered by wind-blown material.

These dinosaurs are important because they were the most abundant dinosaurs of the Triassic and because they gave rise to the sauropods—the most plentiful group of the next geologic period, some of whose members became the largest of all land-living animals.

Coming to our other main division, we find that the ornithischian dinosaurs, or those with bird-like hipbones, were much slower on the evolutionary pickup than were the types we have just discussed. Almost no trace of them has been found in the first period in the Age of Reptiles—only one fragmentary skeleton, found in Colorado, and footprints indicating three other forms. But they must have been quite varied and widely distributed by then, because at the very begining of the next geologic period their remains show definite specialization into two distinct lines.

The second phase in the rise of the dinosaurs took place in the Jurassic period, which gets its name from the Jura Mountains between Switzerland and France, where marine rocks of that age are some 3000 feet in thickness. Gibraltar, too, stands out today as a

great block of Jurassic limestone that had accumulated on the floor of the sea and was brought to the surface by later fracturing of the earth's crust. Thick Jurassic deposits also occur in India, Australia, southern Africa, and South America.

In North America not a grain of Jurassic rock is to be found anywhere east of the Mississippi River. This great region was being worn down, not built up, throughout the period. Just the reverse was true on the west coast, where sediments accumulated in the long, narrow seas that penetrated inland. In what is today the Rocky Mountain region, conditions were different. A vast trough-like lowland was present, with a long, narrow mountain chain to the west. At first this basin was wind-swept and arid, but as time passed, warm shallow waters came creeping in from the north, ultimately reaching as far south as northern Arizona. Just to the south, arid conditions continued to prevail, and vast deposits of wind-blown sands were piled up. Towards the close of the period, the land tilted up, and great meandering streams flowed sluggishly eastward across this region, spreading out a blanket of muds and sands over an area of 100,000 square miles.

Lands of plenty

Along Jurassic streams such as these, on the margins of seas, and in the swamplands densely clothed with vegetation, the dinosaurs evolved abundantly. There were many other forms of life, too,—flying reptiles, turtles, lizard-like creatures, and crocodiles. More than a thousand different kinds of insects—flies, moths, cockroaches, termites, etc.—are known to have lived there. Primitive mammals became more and more numerous, and the first birds appeared. The seas swarmed with invertebrate life. Some coiled mollusks reached a size of six feet across. Schools of great porpoise-like marine reptiles swam along the shores of every continent.

In these surroundings, the dinosaurs began making their first real evolutionary splurge. The Lightweights became more abundant as time went on. Their best-known representative was a creature that stood about two feet high at the hips and was over seven feet from nose to tip of tail. His name, *Ornitholestes,* means "bird robber"—because at his christening it was erroneously thought that his long, curved foreclaws were suitable for catching primitive reptile-like birds. Closer inspection shows no bird-in-the-hand for *Ornitholestes,* for his much elongated and very compact hand probably couldn't have held a bird even if one had flown right into it. He could have eaten birds though, because his small carnivorous teeth were well adapted for such work.

The true Meat-eaters also became more abundant and more widespread during this period. There was little danger of extinction for these marauders in the lands of plenty. They grew to be nearly 40 feet in length and were well able, with their grasping claws and knife-like teeth, to take on even the largest of the giant dinosaurs, called sauropods.

One of the nastiest of these creatures was the North American *Allosaurus,* whose main diet probably consisted of sauropod steaks. Evidence of his slaughterous feats is written on the remains of a large sauropod found in Wyoming. The spines projecting from the backbone of this victim had been bitten off, and the teeth marks match the teeth of *Allosaurus.*

The Land-and-water dinosaurs, or sauropods, are perhaps the best known to the general public. After all, once you see an animal 80 feet long it's difficult to forget it. Not all were as big as that, however,—some were only 40 feet long. The sauropods were by far the dominant group of the Jurassic period.

Not only were they distinctive in their great size, but they were all short-bodied, long-necked, long-tailed, small-headed, literally almost brainless individuals. One of the largest had a brain no bigger than a man's fist. But these creatures were equipped with an additional "brain" that was twice as large as the real brain and was located in the spinal column in the hips. It wasn't really a brain but a sort of relay-station to transmit to headquarters what was going on behind.

The sauropods walked on all fours, that is, when they walked. It is questionable whether they came out on land at all, because the limb joints were of cartilage instead of firm bone. That a 30- or 40-ton animal could support all his weight on such limbs seems unimaginable. It was more likely that they spent all their time in the shallow water along the shores of lagoons and lakes, walking over the muddy bottoms where at least part of their weight was supported by the water.

Stones to aid digestion

Their heads were relatively small and had peg-like or spoon-shaped teeth wholly unadapted to eating flesh but very serviceable for gathering vegetation. They didn't have to eat as much as one would think, however, since their metabolism probably was low. The type of teeth shows that they could not have chewed their food. What they swallowed was taken care of by their gizzard-like stomachs and stomach-stones, or gastroliths *(see page 12)*.

The bodies of these huge creatures were covered with skin having a surface of small, low tubercles, set close together, but arranged in no regular pattern. Discovery of this was made in 1934 by Dr. Barnum Brown when the American Museum-Sinclair Expedition collected parts of some 20 skeletons from the Howe Quarry near Cody, Wyoming.

Quite a number of different kinds of sauropods have been found. The oldest known member is called *Cetiosaurus,* which means "whale lizard." *Cetiosaurus* is, of course, unrelated to the whales, but is a whale of a big dinosaur, for in length he was around 50 feet. He is a genuine sauropod, though in structure rather a primitive one. He makes, therefore, a good structural ancestor for nearly all the later Jurassic forms.

One of the most familiar of later sauropods is the "Thunder Lizard" (***Brontosaurus***). He got to be around 75 feet in length, but the long "whiplash" ending of the tail accounts for ten or twelve feet of that. He stood about fifteen feet at the hips.

For sheer bulk, the champion dinosaur is *Brachiosaurus,* a native of both North America and eastern Africa. Portions of several skeletons—one rather complete—of this spectacular giraffe-like beast are known. The skeleton is mounted in the Berlin Museum. This specimen shows that the tail is short, but

the animal is still 75 feet long. A unique feature of this dinosaur is that his front limbs are longer than his hind ones, which together with a terrifically long neck made it possible for him to nibble comfortably at leaves 40 feet above the soles of his feet!

A large number of other well-known sauropods living at that time were all thoroughly overspecialized for an aquatic or semiaquatic life in humid climates. Nearly all of them died out at the close of the Jurassic, when earth movements drained their lakes and marshes and the climate became more arid. Survival was possible only for those few lucky ones that lived where the old conditions prevailed. They continued on into the next geologic period, and a few managed to survive to the very end of it, when all dinosaurs gave up the ghost.

The plant-eating dinosaurs that dwelt on land in Jurassic times were the descendants of the earlier ornithischian group already mentioned, which now became more important. There are four main branches of these: the High-armored, the Low-armored, the Horned, and the Duck-billed dinosaurs. The Family Tree on pages 8 and 9 shows when they evolved and how they are related. They were rare at the beginning of this period but branched out considerably towards the end.

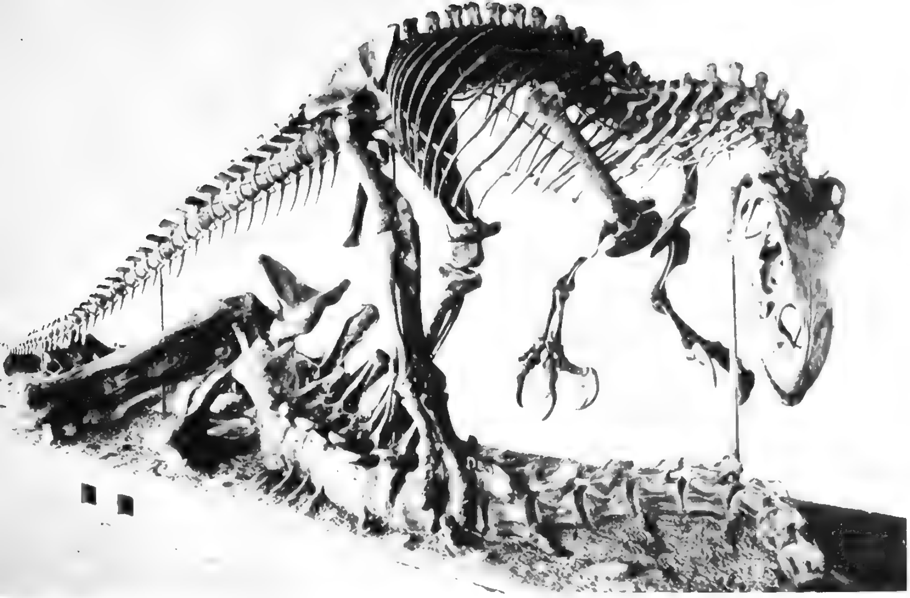
The Duck-billed dinosaurs, quite obviously, had bony duck-like snouts. Some of these dinosaurs, especially the later ones, got to be very large. They all walked on the toes of their hind feet, although certain ones occasionally touched the ground with their hands. The whole skeleton of these animals was massive. The head was relatively large and was equipped with numerous teeth of the chopping type. *Camptosaurus* was the most common and widespread representative of the Duck-billed group at the end of the Jurassic.

The High-armored dinosaurs or Stegosauria got away to a good start at the very beginning of the Jurassic and became a typical feature of the landscape during this time in the earth's history. The earliest one we know, *Scelidosaurus,* had several rows of tubercles and keeled plates along the back, and a row of fairly large vertical plates down along the top of the tail. But his coat of mail wasn't nearly as fancy as that of his descendants, who really went in for decorations. The stegosaurian style-setter was *Stegosaurus* himself, typical of North America late in this period and of occasional occurrence in England.

Stegosaurus got to be 30 feet long, had a little head and a short tail. That little head of his had very little in it, but like the sauropods, he had a second "brain" in his hindquarters—and what a "brain"! In some it was 20 times larger than the regular brain up forward.

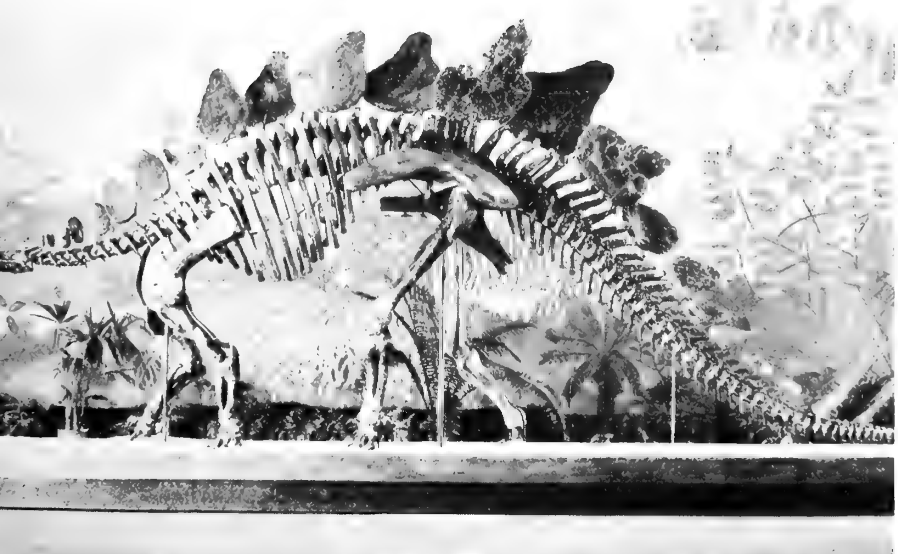
A double row of large plates projected along the middle of the back and onto the tail, at the end of which rose two pairs of long spike-like spines. Of what service these ornaments were to the animal is not certain. Many suggestions have been made. It has even been proposed that they might have acted as a sort of roofing or self-invented shade to protect the reptile from too much sunlight when forced out of the abundant vegetation. They certainly were a protection against attack when dictator *Allosaurus* and his crew took on *Stegosaurus.* And the spines at the end of the tail must have been very effective ankle-busters in combat. Gaudy and homely as these structures seem to us, we may assume that they were attractive to a stegosaurette back in the Jurassic jungles. Furthermore, it must have taken a shrewd Meat-eater to spot one of these creatures with its big, and probably greenish, leaf-like superstructure, half-hidden in one of those Jurassic marshes or in the bush along one of the lakes.

By the end of the Jurassic period, the dinosaurs had risen to unquestionable ascendancy. But the Age of Reptiles was not yet over, and with further environmental changes in store for them, the dinosaurs were destined to have an even greater evolutionary development. With the closing of the period, the earth once again began to tremble. And in their effort to meet new environmental conditions, these most sensational animals of all time entered upon some of their most surprising adventures in the remaining 60 million years of the Age of Reptiles.



A Carnivorous Dinosaur and its Prey *(Allosaurus* and *Brontosaurus).* Though not as huge as *Brontosaurus,* the *Allosaurus* of the Jurassic was a formidable carnivorous reptile which may have preyed upon its larger contemporary.

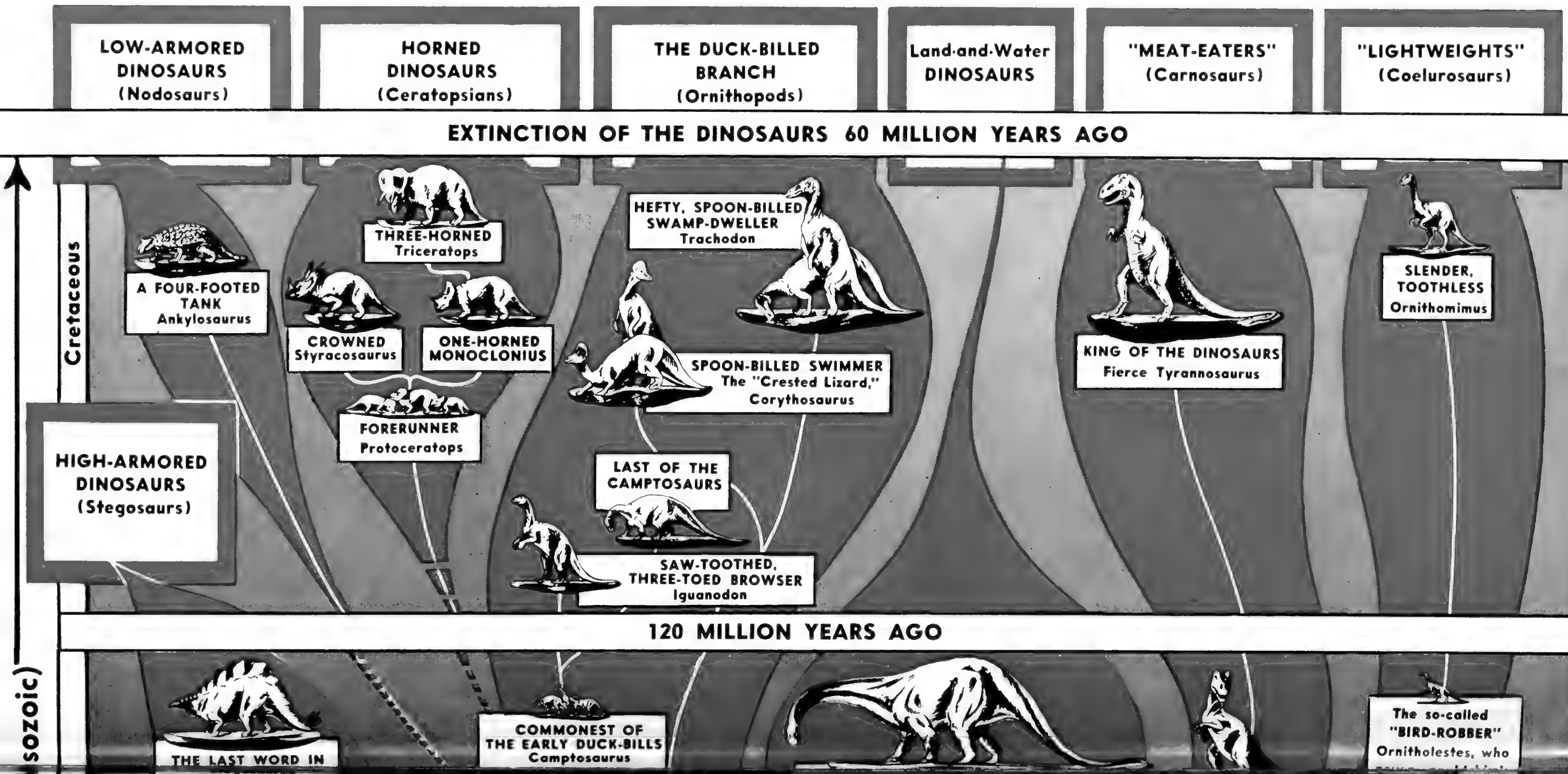
The Duck-Billed Dinosaur *(Trachodon).* These remarkable herbivorous dinosaurs of the Cretaceous Age had a curious duck-like bill used in gathering aquatic vegetation.

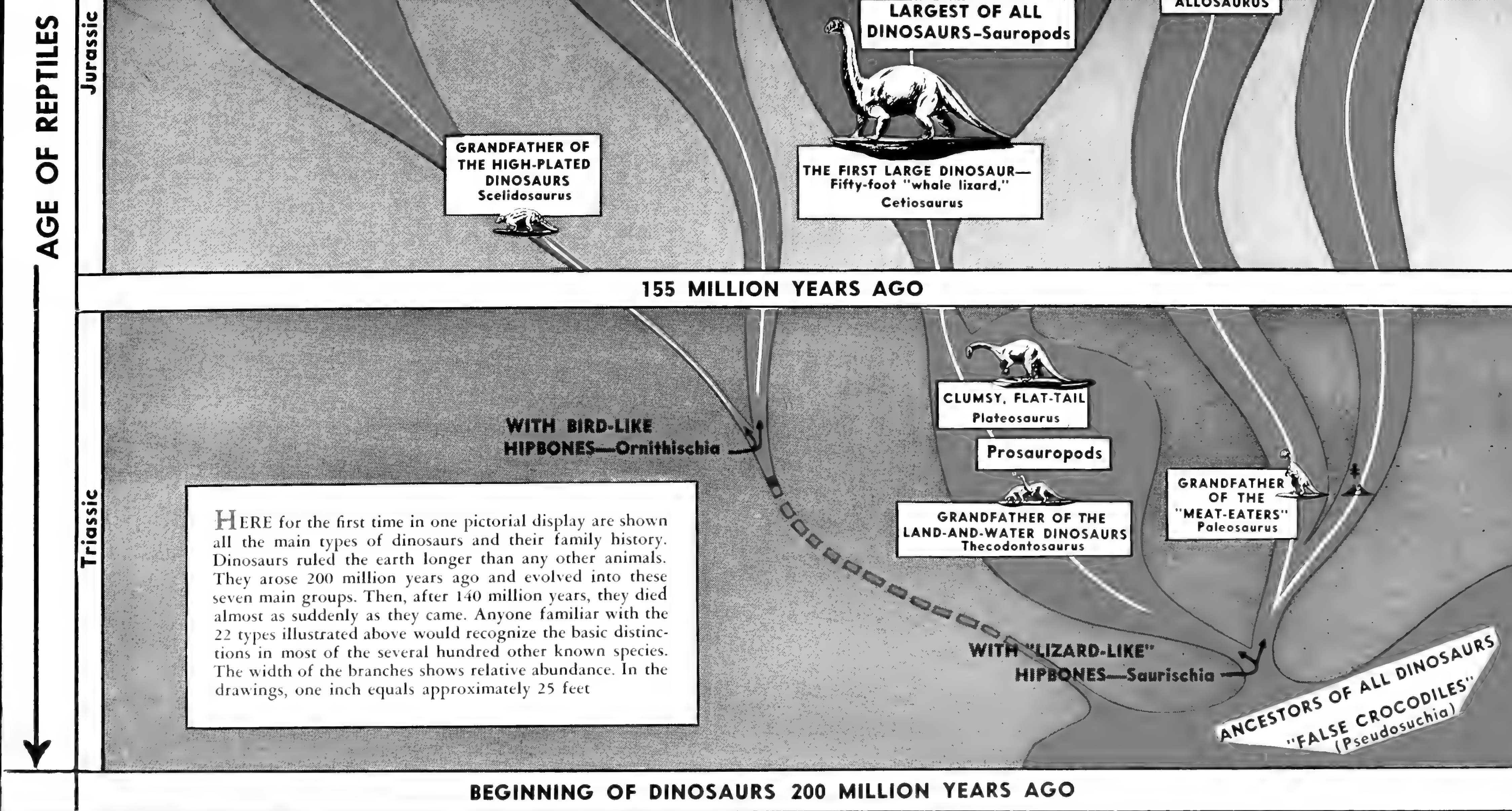


Stegosaurus, a strange armored dinosaur of the Jurassic Period, characterized by its extremely small head, the huge bony plates on its back, and the tail armed with long, sharp spines.

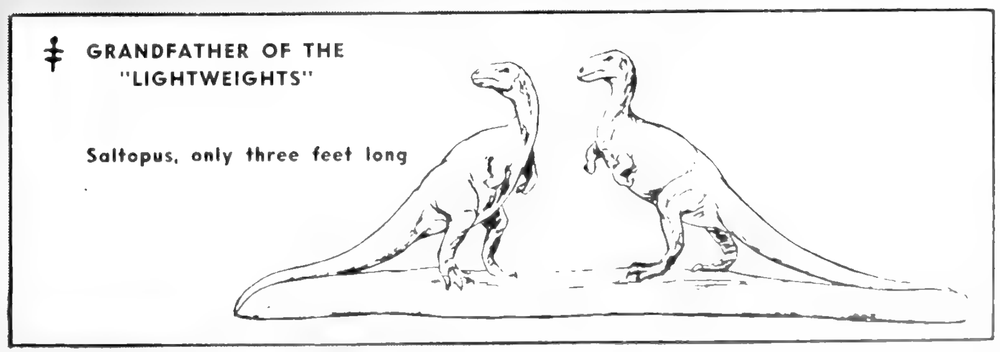
Family Tree of the
DINOSAURS

By BARNUM BROWN *and* ERICH M. SCHLAIKJER





HERE for the first time in one pictorial display are shown all the main types of dinosaurs and their family history. Dinosaurs ruled the earth longer than any other animals. They arose 200 million years ago and evolved into these seven main groups. Then, after 140 million years, they died almost as suddenly as they came. Anyone familiar with the 22 types illustrated above would recognize the basic distinctions in most of the several hundred other known species. The width of the branches shows relative abundance. In the drawings, one inch equals approximately 25 feet



Drawn by
ALASTAIR BROWN
from models by
GEORGIA MARY WHITMAN

THE

In the foregoing article we have seen some of the earliest known representatives of this remarkable group of reptiles and have envisioned the conditions that surrounded them during the first two chapters in their history, through the Triassic and Jurassic periods. The third and final chapter of their life story took place during the Cretaceous period, which lasted for 60 million years. During this time revolutionary earth movements caused portions of the North American continent to rise still higher above the sea, thus reclaiming submerged areas.

The strictly water-living sauropod dinosaurs, which had been so abundant in North America during the preceding period, continued for a short time in the north, but early in the Cretaceous period they died out there owing to climatic changes.

In the area that is now the southern United States, however, climatic conditions favorable to their existence continued, and there they persisted almost to the close of the Cretaceous period—millions of years after they had become extinct in the north.

Back in Jurassic times a typical lakeside scene would have exhibited more of these huge sauropods than any other creatures—slow-moving, cold-blooded reptiles that required little food in comparison to their size. But in the Cretaceous period the glades and swamps were inhabited by more varied types, among which the Duck-billed and the Horned dinosaurs were the most numerous.

TYRANT KING OF THE DINOSAURS, *Tyrannosaurus rex*. This largest flesh-eating animal that ever walked the earth had a sharp nose for blood and carrion, but the days of his rule were numbered

Drawing by ALASTAIR BROWN

LAST DINOSAURS

By Barnum Brown

Curator of Fossil Reptiles, The American Museum of Natural History

It was the era of spectacular armaments, but even Dictator Allosaurus and the four-footed tanks went down before world conditions with which they could not cope

The beginning of the Cretaceous period marked the advent of a highly diversified plant life. Whereas the only type of flowering plants known in the previous two periods were the cycads, the landscape now developed a flora almost as varied and abundant as it is today. Undoubtedly this change in the vegetation influenced the diversification of dinosaurian life during the Cretaceous period.

It is impossible to speak of dinosaurs—a great order of creatures which existed for so many millions of years—without becoming philosophic. They were one of Nature's greatest experiments—a bold venture along new lines. Various forms were tried out, under various circumstances; but after 140 million years, all were thrown into the discard. "All?" you may ask. "Might not some explorer discover descendants of the dinosaurs living today in some hidden corner of the world?" The thought is a romantic one, but I am sorry to say the chances are nil.

Most extinct creatures have left some living descendants or not too distant relatives that give definite clues to their peculiarities and habits, but the dinosaurs left none. As we know them today they suddenly appeared in the Triassic period, 200 million years ago, and they as suddenly ceased to exist near the close of the Cretaceous, 60 million years ago. Our real knowledge of the group goes back only 100 years, when footprints were first found in the Connecticut Valley and were thought to be the tracks of Noah's raven. Since then hundreds of skeletons and incomplete remains of dinosaurs have been classified and exhibited in museum halls, yet every active institution has in its storerooms countless specimens—single bones, fragmentary bones, and teeth—as yet unclassified, of doubtful identity, or entirely new. Many of these, insufficiently understood and too doubtful to bring to light, will remain unpublished until we can learn more definitely of their relationships.

Dinosaurs are so remote from the experience of most people that perhaps the best way to make these dry old bones come to life is to examine the equipment with which Nature endowed them, and to see them perform. If we can see what made the wheels go round, instead of merely pigeonholing them with names and classifications, we may know better what it would have been like to be a dinosaur.

Several hundred species of dinosaurs have been determined; yet we know that these represent only a fraction of the once numerous population. It is indeed a poor season when an expedition does not uncover one or more new species. Realize that all of the combined exposures of dinosaur-bearing rocks represent only a tiny percentage of the accumulated sediments laid down during dinosaur days. Where the dinosaur-bearing beds are being weathered away, each rain may expose specimens previously covered. So we search the same areas year after year and find new specimens. Classic fields will continue to reveal new forms as erosion goes on. And new beds are continually being discovered.

In favorable places dinosaur footprints are found in great numbers, and they are so varied in form that only a few general types have been identified as belonging to creatures whose skeletons we already know. Literally thousands of tracks have been found in the Triassic rocks of the Connecticut River Valley, representing a great many distinct forms. Yet only twelve species of dinosaurs are known by incomplete skeletons from these same rocks.

The rarity of dinosaur bones in this welter of tracks is one of the great mysteries of the past. Possibly it is to be explained on the grounds that the bones were too delicate for preservation in these particular sediments. In spite of their size, the bones of living dinosaurs were probably as delicate as are those of our present-day salamanders. As fossils, the large bones of dinosaurs are extremely heavy, but most of the weight is made up of rock that fills the cavities in the bones—cavities once filled with air. Changed to stone as they are now, it is difficult to appreciate their original lightness and fragility.

In other places, where dinosaur remains were mingled with great masses of vegetation, the skeletons probably were destroyed by humic acid generated during the changes brought about in the formation of coal. Notable examples of this kind were found by the American Museum-Sinclair Expedition of 1937 in the coal fields of Wyoming.

Few skeletons of young dinosaurs

Another mystery connected with dinosaurs is that we find so few bones and skeletons of the young as compared with the vast number belonging to adults. There are only a few cases on record where we can say definitely that the individual was a young animal of a kind known by adult skeletons. Water was necessary for the bones to become fossilized, and it was also essential in the life of the vast majority of dinosaurs. Even semiaquatic creatures of today, such as turtles and crocodiles, lay their eggs away from water. And it has been satisfactorily determined that the egg-laying dinosaurs deposited their eggs in sand

A DINOSAUR TREASURE GROUND

Drawing by Erwin Christman

(Above) A DINOSAUR that looked like an ostrich: *Ornithomimus,* one of the last Lightweights. This toothless animal, which departs so widely from the popular idea of a dinosaur, was about 6 feet tall and may have lived on crustaceans

(Below) GIZZARD STONES. Various kinds of dinosaurs probably swallowed stones which served to grind their food. Here a large number of small stones can be seen among the ribs exactly as found in a small dinosaur in Mongolia

AMNH photo

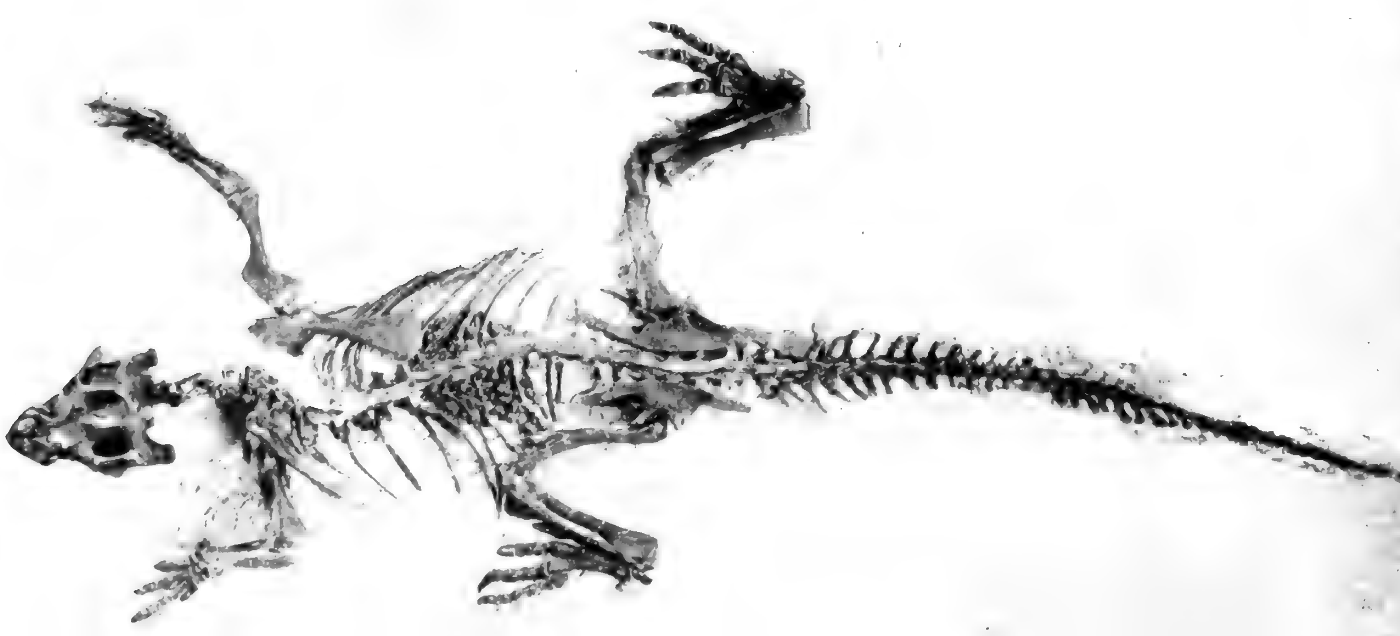


Photo by Barnum Brown

A DOZEN FINE DINOSAURS have been taken out of this one area, 40 miles southeast of Billings, Montana, on the Crow Indian Reservation. Dinosaurs are found where rock edges are exposed along steep slopes. Such exposures represent only a tiny fraction of the total beds laid down during the time of the dinosaurs. Yet it is a poor season when an expedition does not return with one or more dinosaurs new to science

THE OLDEST unaltered animal substance known: skin at least 120 million years old. The left-hand piece shows the actual skin of a dinosaur. The other two, though less spectacular as examples of preservation, both give a clear impression of the surface texture. Sectioned under a microscope, the skin shows a structure similar to the shed skin of a living snake or lizard. Other dinosaurs had distinctive skin patterns like some of our modern reptiles

Photo by American Museum-Sinclair Dinosaur Expedition of 1934

away from water, where they were hatched by the heat of the sun. If the very young died, perhaps they died where there was no mineral-bearing ground water to fossilize their bones.

Other forms, such as the large sauropods, probably gave birth to living young. Among this group there are more specimens that probably represent young animals. The great number of individual remains found together in favorable places and in definite growth stages indicate multiple births as in living reptiles.

How long did dinosaurs live? We can only guess. Their growth and development was probably rapid in spite of their sluggish habits and small consumption of food.

The oldest unaltered tissue

Our efforts to discover what these creatures were like in life are, of course, hampered by many obstacles resulting from the millions upon millions of years separating us from them. But we are fortunate in knowing even the texture of their skin in some cases. Among the huge long-necked, long-tailed sauropods, a section of tuberculated skin pattern was found on a single leg bone in England; and in the great Howe Quarry in Wyoming we found isolated loose patches of skin impression all over the quarry—indeed, impressions not only of the skin pattern but the actual skin substance itself. This has been sectioned and studied under the microscope, and it shows a structure similar to the shed skin of a snake or lizard. This is the oldest unaltered animal substance known, approximately 140 million years old. The surface of this skin is composed of small, low tubercles or bumps, the size of a pinhead, not overlapping as in the scales of fishes or snakes or in the mosasaurian (marine) reptiles. There is no evidence of a definite pattern, nor can we be certain which type of animal this skin covered. But as most of the remains were of barosaurs, the skin in question presumably came from these sauropods—animals that were 50 feet long and twelve feet high, with heads a foot long and brains that weighed an ounce!

Our knowledge of the skin of the Duck-billed dinosaurs—the most numerous of the Cretaceous dinosaurs—is much more specific. We have every authority for saying that the different species could be distinguished by skin pattern as clearly as are the different genera of modern lizards. Many specimens are preserved with the skin impressions immediately overlying practically all parts of the body. So completely do the skin impressions "clothe" two bodies that they have been called mummies, although no part of the actual skin substance was preserved.

Among the Duck-billed dinosaurs, the different areas of the body had different skin patterns—tubercles of characteristic size and shape. Large rosettes were distributed in rows down the belly and upward over the back, with the individual tubercles larger and more uniform in general character over all the tail surface. This wrinkled skin was evidently so tough that when the carcass was covered with soft silts during burial it resisted decomposition for a long time while the silts were hardening, thus forming a clear-cut impression. Later the skin substances decomposed and the impressions were preserved with exact fidelity as to form and pattern. In other species we find uniform impressions without pattern development. At present we are of the opinion that the crested Duck-billed dinosaurs lacked definite pattern arrangement and that some of them may have been variously colored like modern lizards. Probably this group lived for the most part in the water. Sometime in the future when a sufficient number of Duck-billed specimens have been recovered it will be possible to assign definite skin designs to the various species and to identify the creature by them even as we do now by skeletal features.

Among the Horned dinosaurs of the same period several specimens have been recovered with patches of skin impression preserved, and in these forms there is also a definite series of rosette-like patterns on the sides of the belly.

The Low-armed dinosaurs, such as *Ankylosaurus* ("stiff lizard"), were huge, slow-moving armored "tanks," some of them fifteen feet long, five feet high, and six feet wide. The back and sides of these animals were covered with rows of plates running crosswise and lengthwise like those of modern alligators and crocodiles. An epidermis or outer skin, which was similar in form and pattern, covered these plates. Plates of smaller size, varying in form and size so as to permit movement, covered the belly and legs. This numerous and varied group of dinosaurs resembled enormously enlarged, drawn-out "horned toad" lizards.

Gizzard stones

Chickens and other gallinaceous birds swallow stones which serve the purpose of grinding their food in the gizzard or pro-stomach. Some extinct animals such as plesiosaurs regularly followed this same practice, and there is no doubt that certain types of dinosaurs also swallowed stones. A skeleton of an orthopod dinosaur from Mongolia now in the American Museum has 112 stones preserved within the body cavity. With another specimen—one of the large sauropod dinosaurs of the type of *Barosaurus*—seven highly polished stones were preserved with the vertebrae, and it is practically certain that these stones had been in the dinosaur's body when it died.

In some fields where dinosaur skeletons are numerous, as in the Lower Cretaceus beds of Montana, we find literally thousands of highly polished stones that probably were regurgitated by dinosaurs after the stones became rounded and therefore no longer useful as grinders. None of these highly polished stones were found in the body cavities of skeletons from the same beds. We did, however, find such stones while excavating one of the skeletons, and they show the same high polish as those found exposed in the surface layers. In another place where a great number of skeletons were found together, in the Howe Quarry of Wyoming, there were 64 well-polished stones under the shoulder blade of one of the large skeletons.

These are a few examples in which the implication is quite conclusive that some sauropods, as well

as other types of dinosaurs, had the habit of swallowing stones as an aid in digesting food. Our difficulty, however, is to explain the high polish found on the supposed stomach stones (gastroliths), because among the modern birds, hard objects such as glass are etched rather than polished in the gizzard. In our opinion the polishing took place by some unknown process in the alimentary canal of these dinosaurs. The highly polished stones are invariably found in rock layers that contain dinosaur skeletons and they are not found elsewhere.

The teeth of dinosaurs shed much light on their feeding habits. Some dinosaurs like *Ornithomimus* ("bird mimic") were actually toothless and they may have fed upon crustaceans. Those that fed exclusively on flesh were provided with sharp, dagger-like teeth, some of which were smooth on the borders, others serrated.

As among many living reptiles new teeth were grown to replace those broken or lost throughout the life of the individual. The plant-feeding Horned dinosaurs shed their teeth and replaced them with new ones as soon as the enamel-surfaced crowns wore off.

Two thousand teeth

In other groups like the plant-eating Duck-billed dinosaurs, the feeding habits were evidently quite different, since they were provided with a highly complicated tooth system. Some of them had more than 2000 teeth at a time, arranged in the jaws like rows of cartridges in a gun-clip. The teeth were all curved and had enamel only on the outside of the upper teeth and the inside of the lower teeth. Thus the enameled surfaces acted as the blades in a pair of scissors for sectioning the food. As the enameled surface wore down, new teeth came into place at the cutting edge, and the worn roots functioned as a grinding surface. This complicated tooth arrangement must have served a specific purpose, and it seems probable that these animals fed on some highly siliceous kind of plant like "horsetail" rushes, which were abundant during the Cretaceous period.

We marvel at the comparatively small brain in all of these huge creatures. Some of the largest bodied sauropods had the smallest brains, and none could have exceeded ten ounces in content—only about one-fourth the size of a man's.

Casts of the brain cavity have been made from several kinds of dinosaur skulls. Even the semicircular canals, the "balancing organs," have been determined, and in a few cases we have explored the pituitary cavities. It seems probable that dinosaurs as a race were hyperpituitary cases. This, in a measure, may account for their great diversity in form and sizes.

The brain cast of *Tyrannosaurus rex,* "tyrant king," the largest land-living, flesh-eating creature that has ever lived, shows a well-developed fore and hind brain and abnormally large olfactory lobes. This would indicate that some of the carnivorous dinosaurs at least, depended largely on their sense of smell when searching for food, and that they were carrion feeders as well as killers.

Dinosaurs were more plastic than any group of living or extinct creatures of which we have a definite record, and their capacity to meet changing conditions may account in part for their long existence. Most lizards of today can regenerate a new tail if they lose the original one—but there will be no bone in this replacement. The long-tailed sauropod dinosaurs, however, could regenerate not only the soft tissue of the tail but the tail bones as well. One of the sauropod specimens found in the Howe Quarry at Shell, Wyoming, demonstrates this ability, for 21 vertebrae at the end of the tail were "replacements." Several other similar examples of regeneration were found in this quarry.

What happened to the dinosaurs?

Dinosaur remains are found practically over the entire world, but these animals did not get up and travel from one section to another as mammals do when seeking a change of environment. We picture their migration as a slow, gradual dispersal and encroachment into favorable bordering regions—a movement comparable to wavelets where a stone has been thrown into a pond.

The dinosaur race perished all over the world at approximately the same time, near the close of the Cretaceous period. There has been much speculation as to the cause of their extinction, and several untenable theories have been advanced:

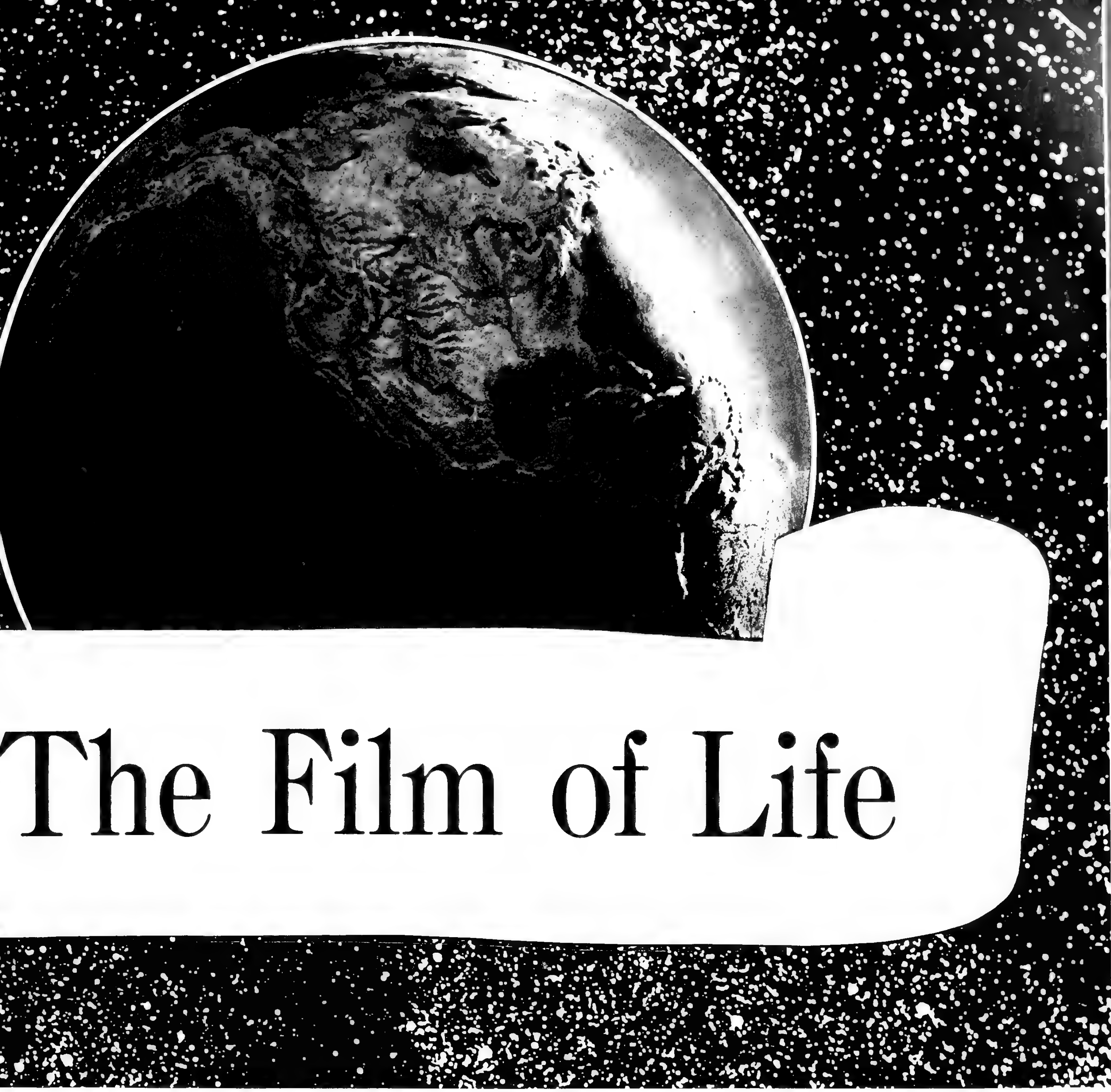
1. It has been suggested that a series of sudden cataclysms such as volcanic outbursts may have exterminated them. But many of the latest survivors died too far from volcanic regions for vapors or even wind-borne ashes to have harmed them.

2. Another supposition is that mammals—progressive newcomers on the earth—might have destroyed the eggs of the dinosaurs. But many kinds of water-living dinosaurs undoubtedly gave birth to living young and were safe from predatory land creatures.

3. Finally it has been argued, that the climate became too hot for the dinosaurs. Modern reptiles, to be sure, cannot stand extremes of heat,—but the plant life at the time of the last dinosaurs does not indicate such temperatures.

The best explanation of the extinction of the dinosaurs follows other reasoning. Dinosaurs had become highly specialized creatures. The plant-eaters were restricted in their feeding habits to certain types of vegetation. When, through regional elevation toward the close of the Cretaceous period, lakes and swamps were drained and plant life changed or became scarce, plant-eaters died out locally, and the carnivores went with them. For they could not migrate rapidly enough to new, favorable places or adapt themselves to a radically and rapidly changing environment.

After all, why should we criticize any group of animals for giving the earth over to other creatures after 140 million years of supremacy? They were amazing creatures, to say the least, and the mysteries still surrounding them will continue to give zest to one of the most absorbing branches of scientific exploration for many years to come.



The Film of Life

The Vertical Extent of Living Things on the Earth

By G. MILES CONRAD

Assistant Curator, Department of Comparative Anatomy

Guide Leaflet Series No. 109

THE AMERICAN MUSEUM OF NATURAL HISTORY

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Roy W. Miner, *Chairman*

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THE FILM OF LIFE

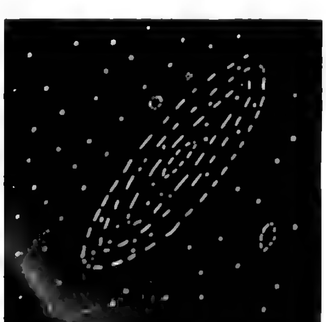
By G. MILES CONRAD

Assistant Curator, Comparative and Human Anatomy, The American Museum of Natural History

Among all the strange things that men have forgotten, G. K. Chesterton once commented, the most universal lapse of memory is that by which they have forgotten that they are living on a star. In all the measureless realms of space, our planet is the only particle of matter supporting any known life. And of this celestial particle, only the thinnest surface film manifests that miracle of which you and every tiniest living cell are a part. The final mystery of life will perhaps never be solved. Whence

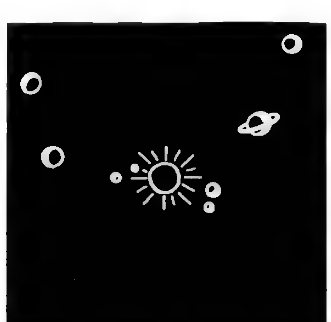
Scattered through the infinity of space are countless spiral nebulae — star systems so vast as to dwarf our solar system to insignificance. From out in space we would have to train our most powerful telescope on a very small part of the right one of these star systems to

1 ↓



see our sun, with its nine planets, of which the earth is one. Singling out the earth, we move closer and see that a hazy atmosphere clings to the surface of the globe, through which we recognize—

2 ↓

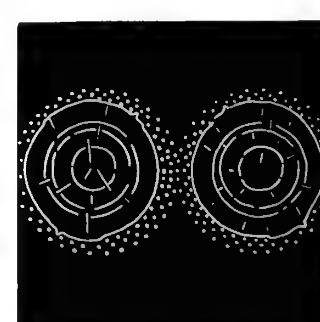


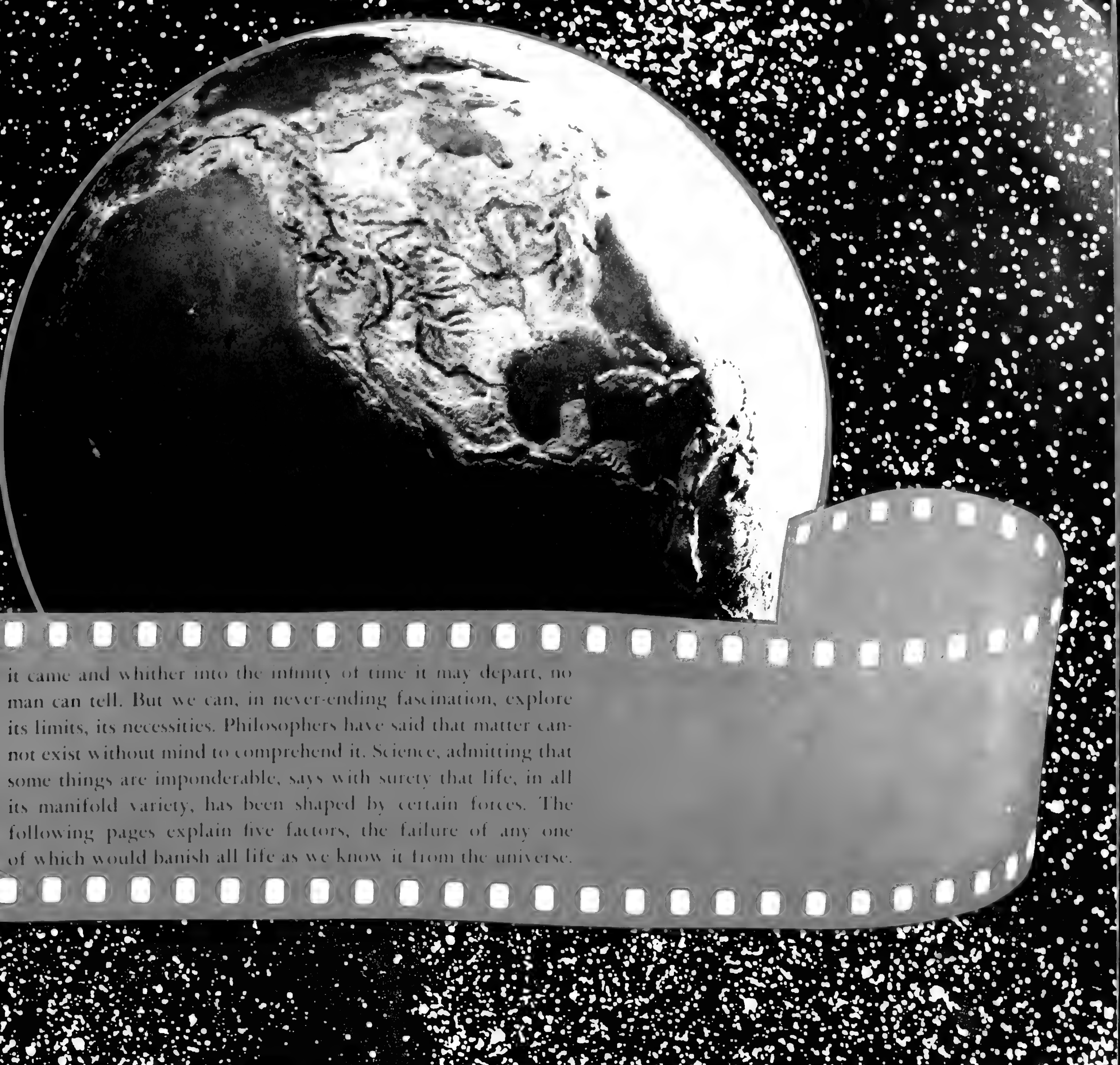
the continents. Solid land makes up 1/3 of the surface, water 2/3. Crawling over and clinging to the sides of this whirling planet is life. The faint green of plants covers large areas; movement of animals is almost everywhere.

3 ↓

If we were to cut the earth in two in our cosmic laboratory, we would find that the liquid surface is but the thinnest coating and that the solid portion is the true core. A few feet underground all life ceases.

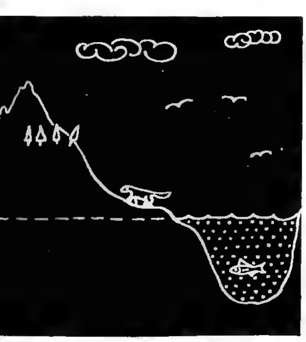
4 ↓





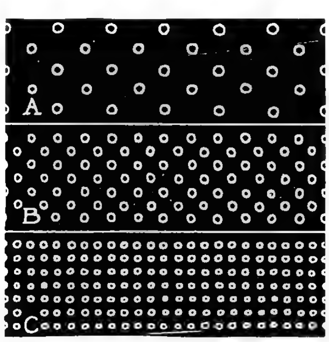
it came and whither into the infinity of time it may depart, no man can tell. But we can, in never-ending fascination, explore its limits, its necessities. Philosophers have said that matter cannot exist without mind to comprehend it. Science, admitting that some things are imponderable, says with surety that life, in all its manifold variety, has been shaped by certain forces. The following pages explain five factors, the failure of any one of which would banish all life as we know it from the universe.

An enlargement of the edge of our earth section where air, land, and water meet, shows that life is confined to a thin "film" about ten miles in depth. This is the only realm containing any known life in the vast immensity of space.



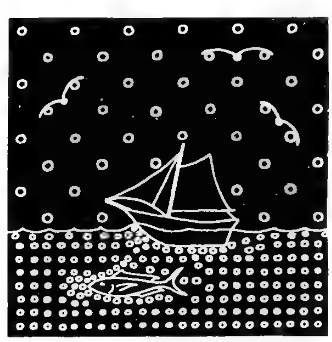
6

We see life in the air (atmosphere), in the water (hydrosphere), and on the land (lithosphere). The molecules making up air (A) are relatively far apart; those of water (B) closer; and those of the lithosphere (C) quite solidly packed.



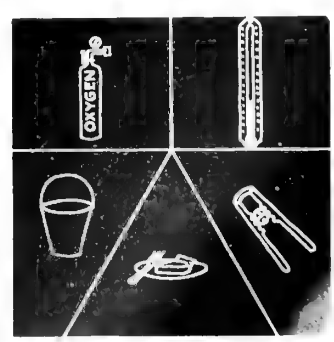
7

The closer together the molecules are, the greater the supporting power, but also the greater resistance to an object moving through the medium. It is harder for a bird to keep from falling than a fish, but it can travel faster.



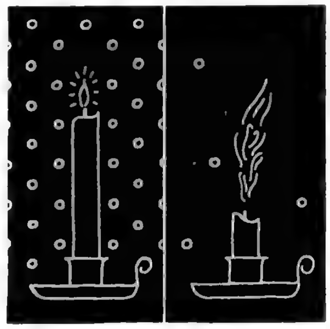
8

At least five factors influence the presence of life whether in the air, in water, or on land. These different but usually interacting factors are (1) oxygen, (2) temperature, (3) moisture, (4) food, and (5) pressure.

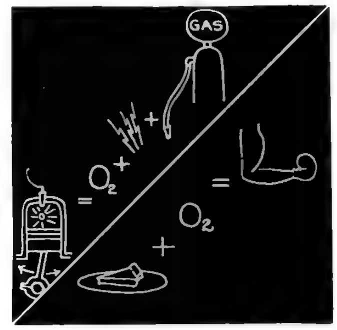


9 Oxygen, as a colorless and tasteless gas, is found almost everywhere on earth. Sometimes it is in combination with other elements but, fortunately for animals, it is commonly found "free" as high and as deep as life can penetrate.

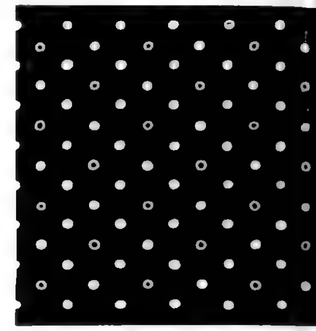
10 Many life processes are "oxidations," in which oxygen combines with other substances in the body to produce energy and heat. A candle flames brightly in a steady supply of oxygen but flickers and dies when the oxygen is exhausted.



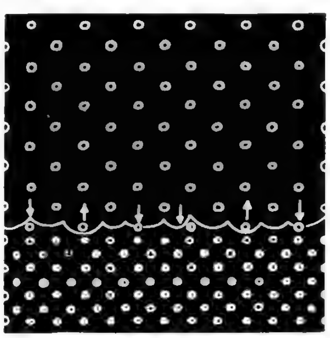
11 Just as the fuel in an engine is ignited in the presence of oxygen to produce energy, so does the combustion of food in the body produce muscular power. Without oxygen, protoplasm — the basic substance of life—disintegrates.



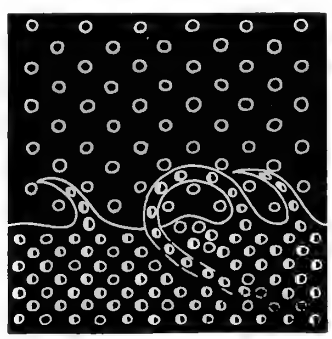
12 At sea level the normal conten of the air is 20 per cent oxygen and 79 per cent nitrogen plus small traces of other gases, such as argon, krypton neon, and so forth. This is more oxygen than is generally needed by animal organisms.



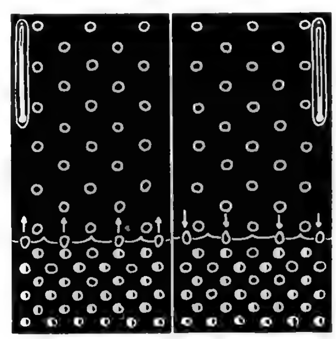
17 Most of the oxygen dissolved in water is derived from the air. It is captured in two ways: by diffusion at the surface and by agitation. Diffusion is a continuous process but too slow to meet the needs of water creatures.



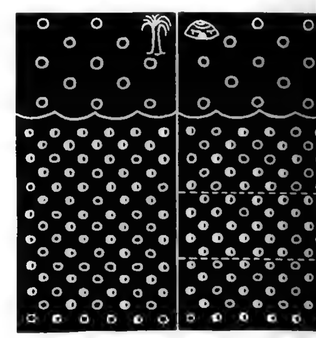
18 But agitation by waves and waterfalls is most effective in supplying oxygen to the waters. Air is captured and pulled under the surface by curling waves. The amount of oxygen water can hold depends on temperature and salt content.



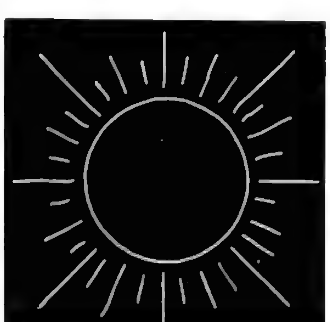
19 Warm water cannot absorb as much oxygen as cool. That is why polar waters support an abundance of marine life, which few people realize. Conversely, water containing a lot of salt cannot hold as much oxygen as fresher water.



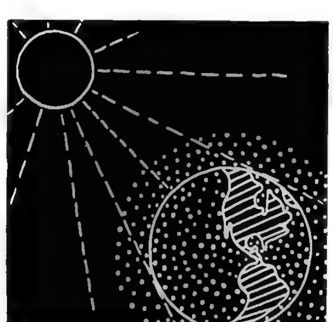
20 The warmth of tropical waters causes them to have relatively little oxygen in the top 1800 feet. But polar waters have three levels: *surface* layer, with much; *middle* layer, with little; and *bottom* with a fair amount. The great depths have none.



25 The original source of all warmth on the earth is the sun, even that of the earth's molten core. This is easily checked when we remember that nights are so often cooler than days, a sunny day warmer than a cloudy one.

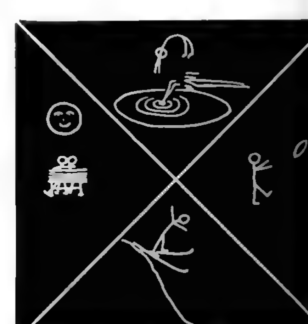


26 Each hemisphere receives the same amount of heat in a year. But where the rays strike vertically they penetrate less atmosphere and are hotter. So, the heat varies with latitude and, since the earth's axis is tilted, with the seasons.

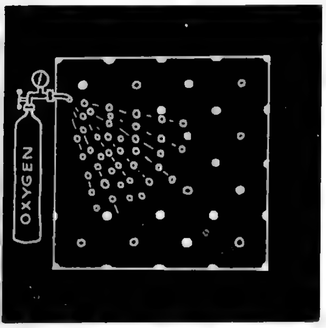


27 Land and water absorb the heat from the sun more readily than air. Indeed, much of the heat from the sun passes through the air to the earth without loss and warms the air only after it has warmed the land and the water.

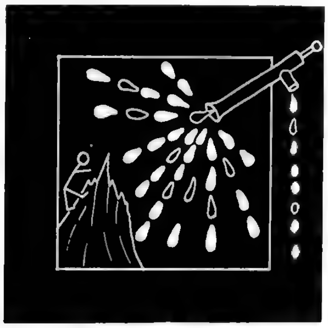
28 When land and water grov warmer than air, they radiat their heat,—causing convectio currents to rise, unequal pres sures to develop, and winds t blow. These things, coupled witl the earth's annual orbit, mak our seasons.



But under the stress of extreme muscular activity, oxidations will apparently proceed more efficiently with 3 or $3\frac{1}{2}$ times the oxygen normally needed. Excessively higher amounts are deadly but are never found in the natural environment.

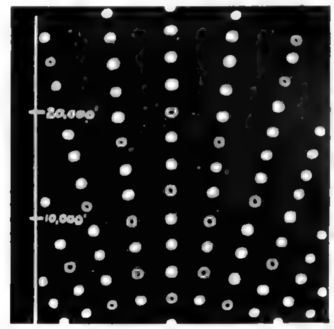


At high altitudes and in great ocean depths, oxygen is deficient. At 18,000 feet there is about half the oxygen there is at sea level, so the heart and lungs must do twice as much work to provide the body with the same amount
14 of oxygen.

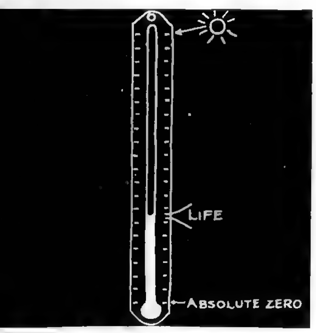


Amounts of oxygen in water vary greatly, and many water animals have developed accessory breathing organs. A number of fishes rise to gulp air. This is dissolved in water, which in passing over the gills yields its oxygen to the
15 blood.

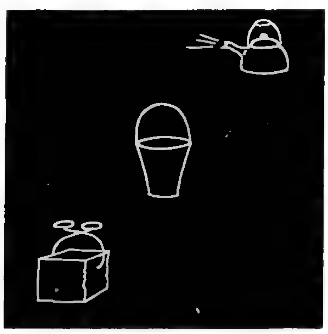
The atmosphere is the main source of free oxygen. The heavier gases, oxygen and nitrogen, hover close to the earth and do not occur much over 35 miles above sea level, the absolute upper limit at which life could
16 exist.



From the heat of the sun's surface to absolute zero are 11,291° F.; and of this, life is limited to a range of 150°, or about 1%. Protoplasm, the basic stuff of life, freezes at 23° F. and coagulates at 158° F.

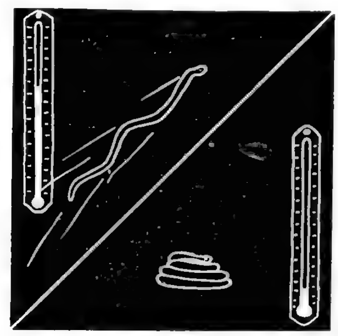


Under different conditions of heat and pressure, all matter may exist as a solid, a liquid, or a gas. If it is not to solidify or boil away, life must remain within the narrow range of temperatures which limit the thin film of life.
22

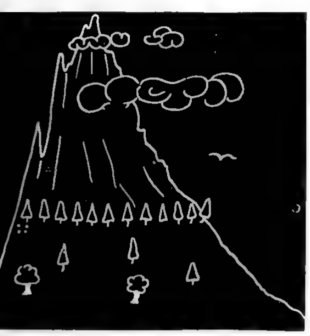


Animals can be divided into two groups: warm- and cold-blooded. The warm-blooded maintain a constant body heat regardless of the weather. This is efficient, because the internal chemical processes can then continue at a con-
23 stant rate.

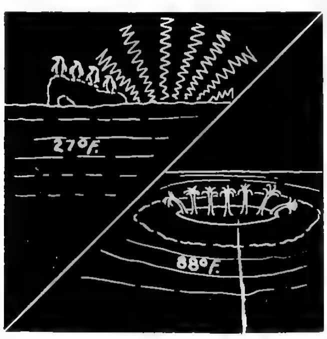
On the other hand, the body heat of the cold-blooded animal varies with the temperature of its surroundings. Thus, extreme of cold or heat will upset the internal chemical balance, and performance will be inefficient and er-
24 ratic.



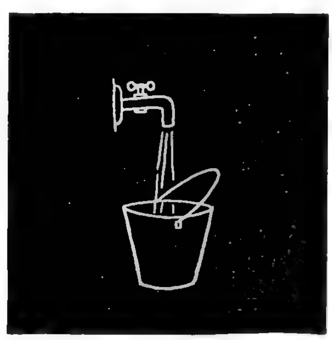
'he higher we go, the colder it rows, until we reach space vhere the temperature is —459° . Snow line ranges from near ea level in the Arctic to 16,000 eet in the tropics; 3000 feet bove this it is apt to be too cold or unprotected protoplasm.



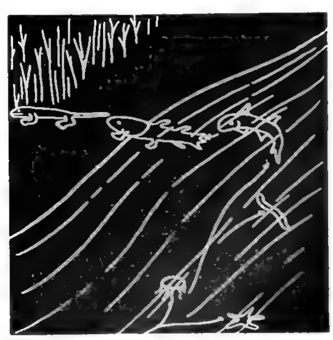
The air does not readily absorb heat and is disturbed by cold and hot winds, hence temperature varies greatly over the earth, from —130° F. to +149° F. But in the oceans, the range is only from 27° F. to 88° F.—*ideal for*
30 *protoplasm!*



Water is never found in a chemically pure state in nature. It is the "universal solvent" in which are dissolved the foods and wastes of living organisms. There is every reason to believe that life originated in the water.
31



Most of the animals that subsequently evolved moved into an atmospheric environment, but none have ever been able to break completely away from the primordial water environment, even after hundreds of millions
32 of years of evolution.



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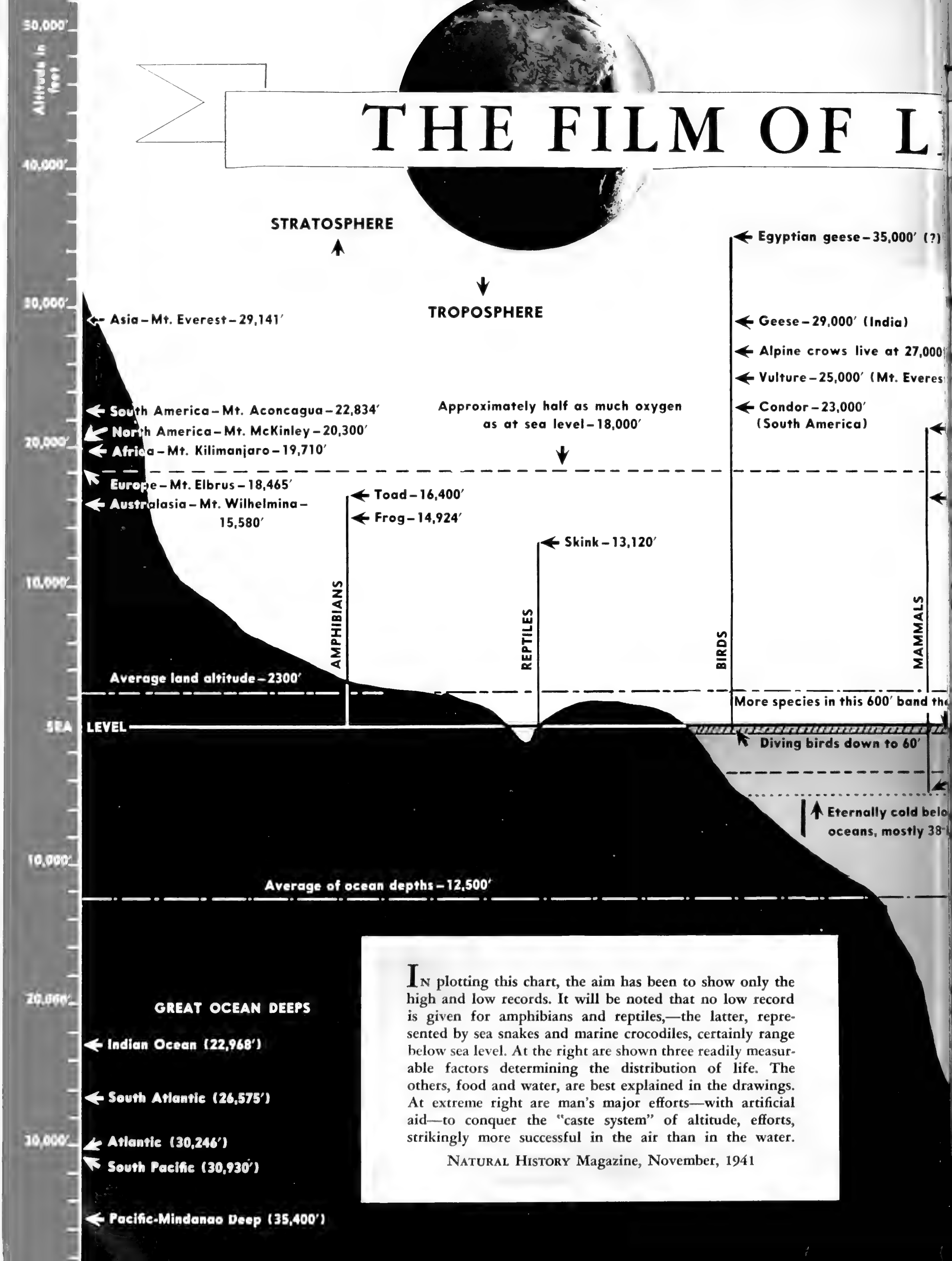
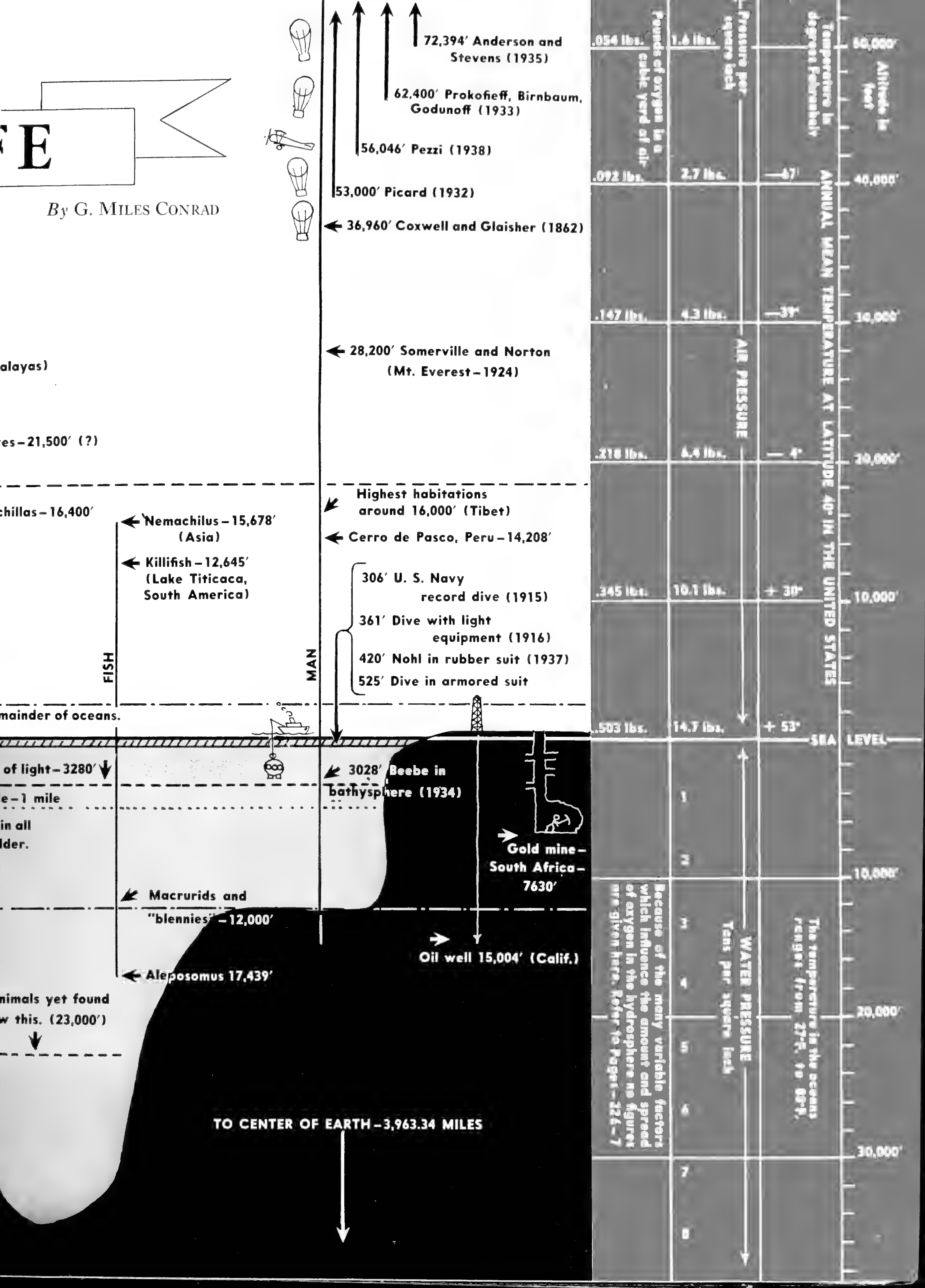


In plotting this chart, the aim has been to show only the high and low records. It will be noted that no low record is given for amphibians and reptiles,—the latter, represented by sea snakes and marine crocodiles, certainly range below sea level. At the right are shown three readily measurable factors determining the distribution of life. The others, food and water, are best explained in the drawings. At extreme right are man's major efforts—with artificial aid—to conquer the "caste system" of altitude, efforts, strikingly more successful in the air than in the water.

Natural History Magazine, November, 1941

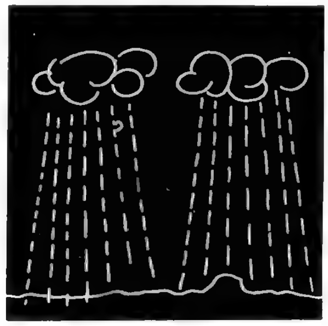
FE

By G. Miles Conrad

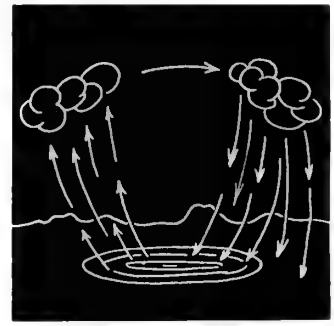


33 Indeed, so tied to the primitive environment are the land animals that they carry fluids in their bodies which contain a percentage of salt similar to that of the seas. To maintain this internal salt solution, water must be available.

34 Water vapor is found up to an altitude of twelve miles, above which no animal could possibly exist. This vapor, derived originally from the hydrosphere, is condensed and precipitated in the form of rain and snow.

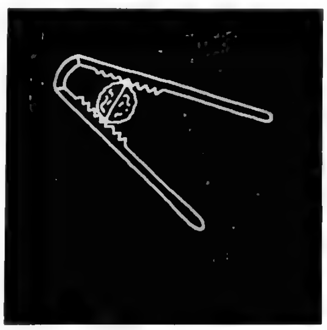


35 The "sprinkling system" of the atmosphere is a perpetual motion process whereby water taken from the reservoir of the hydrosphere (oceans, lakes, and rivers) is redistributed over both the lithosphere and hydrosphere, aiding life greatly.



36 To dwellers in the hydrosphere, water is obviously no problem. Although water is customarily divided into "salt" and "fresh," the distinction is merely a quantitative one, for most fresh waters contain a liberal solution of salt.

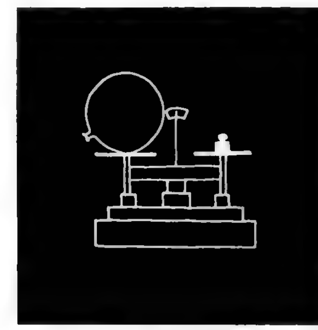
37 Pressure is squeezing or compression; it is the power of our fingers to crack the nut. Life is under constant conditioning by just such squeezing. Normally the internal pressure of an animal equals the environmental pressure.



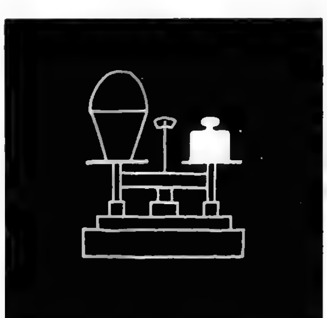
38 But whether the animal lives in air, water, or on land, when it moves toward the earth's center the pressure increases. And if it moves in either direction too rapidly, trouble follows, for the pressure balance is disturbed.

39 If the animal descends too rapidly, external pressure will try to crush delicate organs. If he ascends too rapidly, the body tends to burst. But only animals that travel up or down quickly need special pressure adjustment mechanisms.

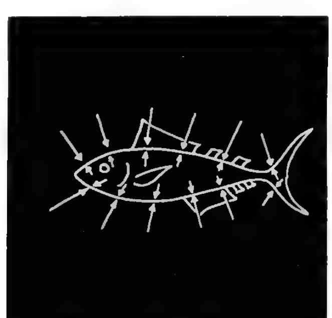
40 The pressures acting upon life are of two sources: air and water. It is hard to realize that air has any weight, but at sea level the 150-mile-high column of air over our heads weighs 14.7 pounds, or "one atmosphere."



41 The higher we go, the lower the pressure becomes, until the vacuum of space is reached. However, a column of water only 34 feet high exerts a pressure of one atmosphere, and a short distance underwater one suffers from the pressure.

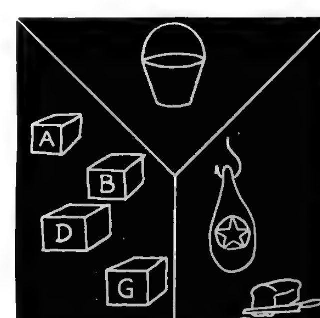


42 In the great oceanic depths, pressures are so great that they are measured in tons. But it must be emphasized that as long as the internal body pressure is the same as the pressure of the environment, the organism suffers no harm.

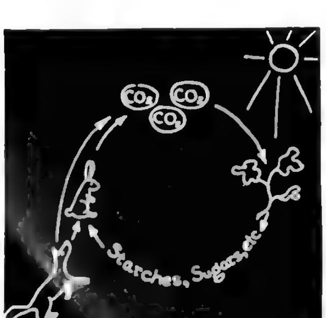


43 Food must provide, (1) the energy for running the living machine and the material for the generation of body heat, (2) the materials necessary for the renewal of worn-out protoplasm, and (3) materials for growth.

44 The stuff used by animals for food is (1) inorganic (water and salts), (2) vitamins, and (3) organic materials (proteins, carbohydrates, fats, and oils). In a sense, food is sun-energy stored by plants and taken by animals secondarily.

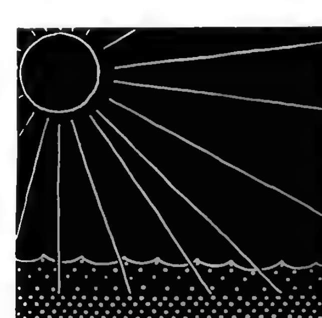


45 Animals that eat other animals are eating food that has all been manufactured from plants. To flesh-eaters, the rabbit is a food factory, transforming impalatable greenery into meat and exhaling carbon dioxide that the plants can use.



46 Plant-eaters are limited in their range vertically by the limits of plant life; but flesh-eaters frequently exceed the plant ranges. The ocean is less favorable to plant growth than the land, because sunlight penetrates only shallowly.

Thus ends our "news reel" of *The Film of Life*, with its five actors —Oxygen, Temperature, Water, Pressure, and Food—limiting the vertical range of animals to a thin film in the vast immensity of space.



THE RISE OF MAMMALS

By
George Gaylord Simpson

THE AMERICAN MUSEUM OF NATURAL HISTORY

THE RISE OF THE MAMMALS

After dominating the world for millions of years the Dinosaurs come to an abrupt end and

THE MEEK INHERIT THE EARTH

By

GEORGE GAYLORD SIMPSON
Associate Curator, Department of Palaeontology

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shaped objects almost exactly like the scales of the living garfish, although fossilization has turned them black. Near by is a prostrate tree trunk, 20 feet long and two feet in diameter with the appearance of fresh wood but completely silicified so that sparks fly if we attempt to sink an ax into its inviting surface.

Great amphibious dinosaurs, crocodiles, fishes, and tall trees in this arid, almost treeless desert! These seem like the wreckage of a different world and so they are. These layers of rock entomb remains from the Age of Reptiles, traces of creatures and plants that died more than 60 million years ago. What is now sandstone was then soft sand, and these hard clays were then oozing mud. More sand and more mud piled up until these beds were deeply buried, and as they compacted and hardened, the remains in them were mineralized and fossilized. Later, much later, the seasonal downpours and the constant winds of this now desert region eroded away hundreds of feet of strata and carved into them the channel up which we have walked. Thus their entombed records were brought to light, so that we now find on the surface the relicts of the savage age of dinosaurs, once deeply hidden in the crust of the earth.

We have not only visited a long-lost world. We have also been walking through time, for as we ascended the arroyo, each higher layer in the piled-up series was deposited at a later time than those below. Each step upward may carry us onward ten thousand years in this record of the history of ancient New Mexico. We have traversed one or two chapters of the time of the dinosaurs, in which different species of those terrible reptiles have succeeded each other without, however, ceasing to be similar. Let us continue up the arroyo, which means also to continue later in time, to see what the next chapter of the thrilling serial may be.

The upper surface of the coarse, dinosaur-bearing sandstone proves to be sharply defined and very uneven. Filling the hollows in it is a bed of brilliant red clay above which, extending far above this to the northeast, is another thick series of red, gray, and green clays, with occasional lenticular masses of white or yellow sandstone. It looks as if the older sandstone had been eroded by the elements long ago and that after an interval fresh floods had deposited mud on this exposed surface. This is, indeed, what happened, and the sharp line between the coarse sandstone and

WHERE NOW there is desert, broad rivers meandered over fertile plains at the beginning of the Age of Mammals, 60 million years ago. The climate was moist and mild in the section of New Mexico depicted below, but mammals have since proved themselves so adaptable that there is almost no climate too rigorous for them. Thus they far outstripped the dinosaurs in adaptability. Below, a turtle—old-fashioned even in that day—looks up at a pair of condylarths *(Ectoconus)*, prophetic of the new era

1

2

3

4

1 Most multituberculates were mouse-like or rat-like, but *Taeniolabis* (about one-third life-size) was almost as husky as a beaver. This group gave way to true rodents

2 There were no exclusively meat-eating animals, but the creodonts were the nearest approach, of which *Loxolophus* was typical. (About half life-size)

3 The condylarths were herbivorous counterparts of the creodonts. *Ectoconus,* shown here at about one-third natural size, is fully restored opposite

4 Least promising were the taeniodonts, represented by *Wortmania* (about one-third natural size). Their descendants became specialized, then died out

the red clay marks the end of one chapter and the beginning of another. We can put our fingers on the exact spot. Mark it well, because it is the visible record of the most dramatic event that ever occurred in the history of the world. Remote as it may seem to us, that was also the most important single event that ever occurred in our own history. If it had not happened, you and I, or anything human, would never have existed.

These upper, later clays look much the same as some far below. In what way do they represent a radical change in life history? Let us search them for organic remains. The most diligent scrutiny reveals no more of the great dinosaur bones. These are all gone, left one or two million years behind us, down the arroyo. But as we adjust our search to a different scale of magnitude we begin to find much smaller bones and tiny, many-cusped teeth, wholly unlike the dagger-like or serried teeth of the dinosaurs.

The hordes of bulky, cold-blooded dinosaurs are gone, vanished as if they had never been, and in their place are other hordes, even more numerous and varied but relatively insignificant in size and apparently feeble in comparison with the least of the lordly dinosaurs. The Age of Reptiles (the Mesozoic) has ended and the Age of Mammals (the Cenozoic) has begun.

The change here appears so sudden that it seems to give evidence for the old belief that the great reptiles, Rulers of the Mesozoic, were wiped out by catastrophic divine wrath and that the earth was repopulated by the creation of a gentler breed. But we now know that evolution, by and large, is a slow process and that when its results burst upon us with seeming rapidity they must be the culmination of long ages of preparation. So it is here. These herds of mammals that so quickly replaced the dinosaurs were not the first mammals to exist but were merely the first to become abundant and widespread.

Since almost the beginning of the Age of Reptiles mammals had existed. They had been small—a mammal larger than a rat was then a giant—and they had been obscure. Probably they were confined to limited areas and to peculiar environments where the competition with the omnipresent reptiles was not too lethal. The result is that they are among the rarest of fossils. Only here and there under exceptional conditions have their remains been found: in a limestone fissure in England, in a single quarry in Wyoming, and in wind-blown sands in the middle of the Gobi Desert. These and a few other discoveries show that mammals did persist during the dark ages of reptilian

dominance and that they were undergoing constant and fundamental evolutionary changes, oppressed by myriad foes, learning perforce to survive by some means other than reptilian brute strength.

The mammals may have contributed something to the downfall of the dinosaurs by eating the eggs of the latter, but they were far too feeble and too few to have been the sole or the most important factor in reptilian extinction at the end of the Age of Reptiles. As related in the December NATURAL HISTORY, the main reason for that extinction was probably that the dinosaurs finally became too sluggish and too inadaptive to meet the conditions of rapid changes in their environment.

The tiny, furry creatures that would have been the objects of scorn had dinosaurs been capable of that emotion, thus inherited the earth. They did so primarily because they were more adaptable. Their adaptability enabled them to survive the crisis of environmental change that slew the last of the giant reptiles. Once these reptiles were gone, this same adaptability enabled the mammals to multiply relatively rapidly and to adopt new modes of life, formerly closed to them by reptilian competition.

Definition of the word "mammal" means a great deal more than naming a few characteristics that enable us to recognize this kind of animal. We must also specify some of the things that enabled mammals to suceed in the struggle for existence and to take over the earth when the reptiles' long day was done. And out of this comes an explanation, partial at least, of why man himself was able to arise and to rule, for we are mammals, too, in one respect the mammals *par excellence*. The most basic mammalian character is intelligence. Small in size, without armor, without large fangs, the earliest mammals survived mainly because they used their heads. Unable to outfight dinosaurs, they outsmarted them. The essential upward trend in mammalian history is an increase in mental power, in grade of intelligence, culminating (up to now!) in man. There are, of course, relatively stupid mammals, and some of these, like the armadillo, have gone back to the old reptilian dodge of retreating into a shell; but the most stupid mammal is a mental prodigy in comparison with the most clever reptile.

The great majority of reptiles lay eggs, and all of them leave the young to fend for themselves from the start. The eggs may be spoiled by too cold a night or too hot a day, and eggs and young alike are peculiarly liable to attack by marauders against which their defenses are poor. With only two exceptions, mammals bring forth their young alive, reducing the hazards of the embryonic period to a minimum. Without exception, the young remain with the mother for some time and are nourished with her milk and protected by her against enemies. This not only enormously increases the young mammal's chances of survival but also gives it a relatively sheltered juvenile period in which it can adapt, learn, and acquire behavior patterns more complex than the almost entirely instinctive reactions of the young reptile. This opportunity to learn is related to the ability to learn—no mammalian characteristic is an isolated thing, but all are intimately correlated to produce a higher type of physical and mental functioning. The complex of growing intelligence and of juvenile care also involves the rudiments and the possibility of peculiarly mammalian sorts of conscious social structures, which again culminate in human society.

The more strictly physical structures and functions of mammals also differ profoundly from those of the ancestral reptiles. Mammals early acquired a complicated physiological mechanism for maintaining nearly constant body temperature. Thus they can survive and remain active in weather so cold that reptiles become dormant and finally freeze to death or in weather so hot that reptiles die of a sort of sunstroke. There is almost no climate so rigorous that mammals cannot somehow become adapted to it—this is probably the major secret that enabled the mammals to survive the great dying time of the reptiles at the end of the Mesozoic. Greater mammalian activity is also forwarded by improved bony and muscular structure. A mammalian thighbone, for instance, is more finished and more specifically adapted to special functions than is the corresponding bone of a reptile. A skilled mechanic at once recognizes the mammalian bone as being a better job. The mammal is capable of faster, more continuous action.

All these things—suckling the young, maintenance of body temperature, sustained activity—require a more rapid and constant utilization of energy within the mammal's body. This higher metabolism also implies a more steady food supply and a more efficient use of it. The whole body is involved in these activities, but we see them reflected most clearly, especially when dealing with fossils which preserve only the hard parts of animals, in the changing structure of jaws and teeth. The complicated reptilian jaws are made of many different bones, mechanically complex but so put together as to permit only a limited repertory of motions. In mammals the lower jaw is a single bone, strong and simple, with very wide possibilities of movement. Dinosaurs could not chew; they could only rend and chop with their teeth. In conjunction with their new jaw structure, mammals early acquired a peculiarly potent pattern of cuspidate, or pointed, teeth. This pattern was amazingly adaptable. Emphasis on one element or another in the process of evolution could produce specialized jaws equipped to take care of the most extreme varieties of food, each with maximum efficiency. Thus the mammals could find plenty where many of the reptiles would starve to death.

Those are some of the reasons why the humble, furry, little mammals were able to inherit the earth when their great chance came—when the going became too hard for the stronger, more abundant, but clumsier, less efficient, and less adaptable reptiles. Of the dozens of different kinds of reptiles in the Mesozoic very few survived into the mammalian age of the Cenozoic. None of the biggest reptiles could make the transition. Those that did survive — lizards, snakes, turtles and crocodiles—had the fortune to be adapted to environments that changed less radically and to ways of life in which they were less at a disadvantage in comparison with mammals.

Let us return to New Mexico and see what life was like there at the beginning of the Age of Mammals. The climate was certainly more moist than it is now and perhaps more equable. Broad rivers mean-

dered over the fertile plain that is now a desert, and groves of lush trees and shrubs abounded where scraggly sagebrush now grows.

Among the swarms of mammals, there is only one that is at all familiar to our eyes: a little opossum; for the opossum is the great conservative among mammals, an almost unmodified survival from the Age of Reptiles. The time is so remote that all the other animals have since either become extinct or have evolved into something unrecognizably different. It is difficult to describe these early mammals by any names derived from the recent fauna. It cannot be said that such and such an animal was an ancestral horse, because that ancestry was not yet sufficiently horse-like to be distinguishable, or that another animal resembled a cat, because the special cat-like habits and structures had not yet been differentiated. There is really no alternative to coining distinctive names for the ancient groups of mammals, and in this archaic New Mexican landscape most of the mammals we see are multituberculates, creodonts, condylarths, and taeniodonts.

Most of the little multituberculates were mouse-like or rat-like, although at this particular time some of them had achieved considerable size and were as large as husky beavers. They had enlarged, more or less rodent-like incisor teeth, and their cheek teeth were grinders covered with rows of tubercles—hence the name "multituberculate." The smaller kinds had also a set of large, sharp, scissor-like teeth in the middle of the jaw, for slicing off the skin and rind of fruits and vegetables. In that world the multituberculates played the part the ubiquitous rodents do in ours, but they were not true rodents. They were then the oldest type of mammal, a survival from the still dimmer past of the early part of the Age of Reptiles. Somewhere, as yet undiscovered, true rodents were probably even then beginning to evolve in obscurity. When their typical structure was well developed, they spread rapidly over the world. When this happened the multituberculates quickly became extinct without issue, for the habits were similar and the rodents were more efficient in the ensuing competition.

The carnivores and herbivores of today differ from each other so much that the thought of mistaking one for the other is ridiculous. Who could think that the fierce, flesh-eating tiger might be blood brother to the placid, grass-consuming cow? But in this ancient New Mexican fauna this specialization and differentiation of habits was barely beginning. The carnivores of the time — called creodonts — were less carnivorous, and the herbivores—condylarths—less herbivorous. There were no exclusively meat-eating animals like the tiger and no grazing animals like the cow. (In fact there were no grassy meadows to graze on; the meadows came later and with them, with typically mammalian adaptability, evolved grazing from more primitive browsing animals.)

Thus the creodonts and condylarths all looked very much alike, differing only in size and proportions and in minor anatomical details clear only on careful study. They were almost all rather squat, heavy-limbed animals with five toes, each ending in what was neither exactly a sharp claw nor a blunt hoof but something between the two. Their heads had more or less the simple proportions of the head of a dog or a bear, although not as pointed; but the braincase was smaller because the brain itself was still very primitive in comparison with the brain of later mammals. Their tails were long and clumsy, slowly tapering from an unusually heavy base. These animals varied from about the size of a rat to that of a police dog—there were no really large mammals as yet. Many of the smaller forms lived mostly in the trees, while the larger ones ambled about in the forests and glades.

A few of the creodonts were already specialized to the degree that they preferred a diet of carrion and only resorted to other food under the sharp stimulus of hunger; but most of these animals, creodonts and condylarths alike, were more or less omnivorous. Probably all of them ate some carrion when they found it. The more active creodonts may occasionally have been able to kill a multituberculate or an unwary condylarth. They all doubtless relished berries, fruits, and nuts. Some of the larger condylarths probably also relied heavily on succulent leaves and shoots in their diets.

Primitive as they were, these relatively clumsy mammals were full of promise for the future. The creodonts exemplified a type of structure that was capable of progressive adaptation into all the diverse sorts of later carnivores, and the condylarths foreshadowed the even greater diversity of later herbivores.

The other conspicuous members of the fauna, the taeniodonts, held no such promise. They were already beginning to specialize in a peculiar way that did, indeed, continue and intensify for some millions of years—but eventually it proved fruitless when the stock died out without further descendants. They exemplify a sort of unsuccessful experiment in adaptation, an early, aberrant line of specialization. The smaller, more primitive taeniodonts differed little from the creodonts, but the more peculiar large forms, with nearly the size but not the form of a collie, were still more strange. They had snub noses, heavy, deep jowls, strong, gnawing canine teeth, and large, blunt cheek teeth. Their bodies were peculiarly heavy and clumsy and their strong limbs, terminating in large claws, seem to have been adapted to digging and tearing up roots.

More progressive animals do not appear in this first, archaic fauna of the Age of Mammals as revealed by the famous fossil field of New Mexico's San Juan Basin. But somewhere, still isolated and hidden, they were already beginning to arise. As the millennia passed, from time to time some of these burst the bounds of environmental and geographical isolation and spread over much of the world. Thus in a few million years the modern true carnivores were to spread and, after a long struggle, to oust the survivors of their ancestral group, the creodonts. The early four-toed horses and other ungulates were similarly destined to replace the condylarths. Most significant of all, and sooner than the incursion of more advanced carnivores and ungulates, was to be the appearance of the primates, tiny lemurs and tarsiers, first forerunners of the long line leading to Man.

Be sure to read the next installment of the story of animal life in NATURAL HISTORY *for March.*

Painting by Francis Lee Jaques

Sixth installment in the story of animal life

Both North America and Europe became the scene of conflict some forty or fifty million years ago when a host of new animals swarmed in, possibly from Asia, menacing all those who could not defend themselves

NO MONKEYS appeared in the vanguard of the invasion, but their ancestors the lemurs were plentiful. A typical representative about forty million years ago was Notharctus, at left. Monkey-like hands, feet, and tail are characteristic of the lemurs, but the face is more fox-like. Lemurs did not survive in North or South America, but they are fairly abundant elsewhere today

No newspapers carried the headlines:

AMERICA INVADED

SHOCK TROOPS SWEEP FORWARD

INFILTRATION TACTICS THREATEN DEFENDERS

AMERICANS FALL BACK WITH STUBBORN RESISTANCE

THERE were no reporters to cover this great invasion. No human eye saw it, for it occurred long before man had appeared on the earth, tens of millions of years ago: some say 40 million and some say 50 million. Yet it had a greater effect on history—yes, on human history as well as on earth history—than any of the military campaigns of the mere six thousand years or so of what we are pleased to call history.

It was not the first invasion of America and it was not to be the last, but it was in many respects the most fateful. Already incredibly old, the earth had seen many races come and go. Perhaps a billion years before this, the first protoplasmic life had moved in the dark waters. Slowly, gropingly, as aeons passed, cells had clustered together, had formed muscles, skin, nerves, and glands. Fishes appeared, equipped with a wonderful new structure, bone, that gave them internal support, solving the problem of increased size and of greater speed, providing rigid support and yet giving freedom of directed motion. Crawling out of fetid pools, gasping for oxygen, the amphibians had finally learned to breathe air during their adult life; and some of their descendants, the reptiles, had completely broken the long bondage to water, for even their eggs could be laid on land and could survive without the watery bath required by all the earlier forms.

Then had come a great time. Surely an observer, had there then been one capable of rational thought, would have decided that the goal of evolution was reached. Through the air flapped and soared ugly, bat-like pterosaurs. Swift as torpedoes, streamlined ichthyosaurs sped through the waters, while marine dragons, the mosasaurs, sported with them, and the clumsier plesiosaurs sculled more placidly along. Above all, on land the motley hosts of dinosaurs held sway. Yet all these saurians were but an incident in history, even though a long incident of perhaps 140 million years, and they vanished mysteriously and were as forgotten as if they had never existed, until their remains were dug up by curious men.

That long time when the dinosaurs and all the other -saurs lived and dominated life is called the Mesozoic. The name means "middle life," and appropriately refers to the Medieval Era, the Dark Age, of earth history. When the saurians died and the meek mammals replaced them as previously described in this leaflet, the Cenozoic began, the "recent life" era. This was the beginning of modern history in the grand history of life, in which ten million years is like a century of human history. When students delving in the rocks first obtained some grasp of this sequence they found what seemed to be a fairly simple picture despite the multiplicity of its details. The dinosaurs were gone. Very well, that ended the Mesozoic. Mammals became abundant and no doubt they simply evolved into living faunas. So the period of that evolution can be called the Cenozoic, and for its first part no more appropriate

The Great Animal Invasion

By George Gaylord Simpson

Associate Curator of Vertebrate Paleontology, The American Museum of Natural History

name could be used than Eocene, which means "the dawn of the recent."

Now it is a troublesome fact that the more we know, the more we find to be known; the more we understand, the more appears that we do not understand. If they are acquiring some measure of wisdom and not merely being educated, students are likely to discover this distressing fact about the time they get into high school. Scientists, who are professional students and are paid for trying to find out a few of the multitude of things that ignorant man does not know, live all their lives with the discouraging conviction that their most distant journeys into the unknown are not much more extensive, relatively, than if they were ants setting out to explore North America.

All this is by way of introducing the news that paleontologists had hardly named the Eocene and started the interesting task of tracing the descent of animals from that time to this, when they began to find fossils that did not fit into the picture. They found that the Eocene did not immediately follow the extinction of the great reptiles at the end of the Mesozoic, but that some time intervened. The longer they studied, the longer this interval appeared to be, until now it is believed to have lasted for at least ten million years, possibly fifteen million. Rocks deposited in that interval are not very widespread; but now almost a complete sequence of them has been found in our Rocky Mountain states, and some strata representing more limited parts of the interval have also been found in Europe, Asia, and South America. Fossils occur in these rocks and they show that mammals were the dominant, common animals of the time.

So far, so good. This unexpected interval belongs to the Age of Mammals and fits into the Cenozoic. The name Eocene had already been given to a later epoch before it was found that this was not really the beginning of the Cenozoic, so a new name had to be coined for the true beginning and it has been called Paleocene, which means "ancient-recent." It is a rather absurd appellation if taken literally, but paleontologists agree to use it, and it serves all the purposes of a name and is less confusing than if the

No one knows just where the invading animals came from. South America, then separated from North America, avoided the invasion until several million years later

Drawing by John C. Germann

The grotesque archaic uintatheres *(center)* were doomed to extinction when faced by progressive invaders like the ancestral horses *(right)*

use of the more appropriate "Eocene" had been changed.

The trouble was that the mammals of this unexpected extra epoch, the Paleocene, do not simply grade into the ancestry of modern mammals. Something very queer, and at first sight inexplicable, happened at about the beginning of the Eocene. Take the ancestry of the horse, for instance. Everyone knows that this can be traced back almost continuously to little Eohippus, a small animal with four front and three hind toes that lived in Europe and North America at the beginning of the Eocene, the "dawn-horse" in the "dawn of the recent." But where did Eohippus come from? Since the long Paleocene, with its varied mammals, preceded the Eocene, obviously it is the place to look for the ancestor of Eohippus.

There are, indeed, animals in the Paleocene that could have given rise to Eohippus. These are the condylarths, the first hoofed, herbivorous mammals, described in the first part of this leaflet. The problem seemed to be solved, but paleontologists continued to pry and they learned so much that they found that they knew less than they had thought. They found that the condylarths evolved slowly and steadily through the Paleocene but that when Eohippus appeared the condylarths were still here and were still much more primitive than Eohippus and quite different. Apparently these condylarths, at least those known in North America, did not evolve into Eohippus. The same sort of difficulty appeared not only for the horses, but also for all the modern types of herbivores, the pigs, cows, antelopes, and the rest, and for the rodents and for many other recent types of mammals.

Here are the makings of a game more exciting than "Murder" and more difficult than crossword puzzles. The reader can try it, if he likes, as a superior sort of guessing game. The question is: *Why does the first animal we can class as a horse differ so much from its only possible known ancestors?* The scientific method of attack on the problem does, indeed, follow some of the lines of a guessing game. A first step is to think of all conceivably possible explanations. In scientific research these are called "multiple hypotheses." You might try this yourself before reading the multiple hypotheses that scientists have set up for this particular problem. The most important of these hypotheses are:

Some of the invaders, like the great titanotheres *(below)* progressed so rapidly that they, too, became specialized and then extinct

Paintings by Charles R. Knight

FIVE HYPOTHESES are considered in explanation of why horse ancestors appeared suddenly in North America. They are:

1 that Eohippus, the Dawn Horse, was created by divine act

2 that the geologic record in North America was interrupted during the time when Eohippus was evolving

3 that certain animals, unlike Eohippus but related to him, suddenly gave birth to a litter of Dawn Horses

4 that fossil hunters in North America have as yet merely failed to find the connecting links in horse ancestry, and

5 that the Dawn Horse was evolved elsewhere than in North America and arrived on this continent along with other invading animals

1. Eohippus was created by divine power and did not evolve from any earlier form. This was accepted by scientists a hundred years ago and is still claimed by a few theologians, but it cannot now be seriously considered by any thoughtful inquirer. This is no place to go over the threadbare arguments, but if you feel like arguing, mull over just one fact: the whole sequence from Eohippus to modern horse is very well known and shows beyond question that the latter is derived from the former; but some condylarths are much more like Eohippus than Eohippus is like the modern horse.

2. Eohippus did arise from condylarths in a (hypothetical) long interval between Paleocene and Eocene when no known rocks, and hence no known fossils, were deposited. This is a plausible hypothesis, but, as it happens, one that can now be disproved beyond any doubt. One of several conclusive lines of disproof is this: condylarths are known both in the late Paleocene and in the early Eocene contemporaneous with Eohippus; they are very much alike in the two epochs; if they changed so little, no length of time sufficient for the slow origin of Eohippus can have intervened.

At which point you may interrupt me to say, "How about the scare headlines with which you began this article. Was that just a come-on to get me to plow through all this stuff?"

"Not at all," I would answer. "This 'stuff' as you call it, has a very direct bearing on those headlines. We'll be back to the invasion sooner than you expect."

3. Eohippus did arise from the condylarths, but did so all at once and not slowly. Perhaps condylarth mates suddenly had a litter of Eohippuses at the beginning of the Eocene. In the nature of things, this hypothesis cannot be ruled out categorically and some respectable scientists (as it happens, not those best acquainted with the facts of mammalian history) do support it. Nevertheless it is so improbable as to be unacceptable unless we can find no hypothesis more likely to explain the observed facts. No such radical jump ever occurred in the later evolution of the horse, or in any other group represented by a good fossil record, so what logical right have we to assume that it happened here unless there is no other explanation?

4. Some line of American condylarths, evolving more rapidly than those known, did give rise to Eohippus during the Paleocene but simply has not been discovered. Again, the hypothesis cannot be disproved—who can say what may yet be discovered? It was even a likely hypothesis before much was known about the American Paleocene, but as hundreds and thousands of Paleocene fossils are found, many of them clearly from environments suitable for Eohippus, and not a scrap of a real Eohippus ancestor appears, the chance that such ancestors occurred here is being reduced to the vanishing point.

5. Eohippus evolved from condylarths some place else and it appears suddenly at the beginning of the American Eocene because something—perhaps the rise of land joining various continents—then permitted the herds of Eohippuses and other typical Eocene mammals to invade North America.

This is the favored hypothesis of paleontologists. It explains all the known facts, no fact contradicts it, and it is supported by other observations and theories on all sides. Thus it becomes something more than a hypothesis (which is a scientific guess set up for examination and testing) and becomes a full-fledged theory (the most probable, best supported explanation of a body of observations). The next step —from theory to an attested fact—would be the finding of the ancestry and the tracing of the actual steps of the invasion radiating from a center. Such a discovery has not been made. Perhaps it never will be. It is quite possible that the center of origin is now sunk beneath the sea or that no fossils survive in it. But in any case the theory is established and seems almost certainly to be true.

Ancestors from abroad

With a few exceptions, the known American Paleocene mammals were archaic types. They were related to the ancestry of later mammals and give us some idea of what those ancestors were like, but they were not themselves the real, direct ancestors. Life today would be very different if the Paleocene mammals had continued to occupy the earth and to evolve into the only living types. Hardly a single mammal that we know today would have existed. The ancestors came in during the Great Invasion.

This did not happen all at once. Some groups invaded earlier, some later, but the climax of the change came at about the beginning of the Eocene, so that the name of the "dawn of the recent" epoch is still appropriate. The archaic Paleocene groups did not die out all at once, either. Most of them were certainly doomed, because they were less efficient or less intelligent than various modernized mammals of similar habits and could not win in the long competition. Nevertheless many of the archaic mammals hung on, some of them for millions of years, and continued to evolve in their own ways before they finally succumbed.

Let us briefly review a typical mammalian fauna of, say, the middle Eocene when the invaders were well established but some of the ancient inhabitants were still holding out. A good example is the fossil fauna of the Bridger Basin of southwestern Wyoming. In the middle Eocene much of this region, now barren, was heavily forested. The animals roamed through the forests, glades, and smaller savannahs of a broad valley. Distant volcanoes thundered; falls of volcanic ash were frequent, but seldom so dense as to cause wide slaughter. To the south was a lake basin already almost filled by millenniums of ash falls and by the sediments of rivers but still with shallow open water in the middle Eocene.

To the instructed eye, perhaps the most striking animals of the time were some of the smallest, the rodents. The rodent-like multituberculates of the Mesozoic and Paleocene were among the first of the archaic mammals to fall before the invaders. Now,

in the Eocene, they are all gone and in their places are multitudes of true rodents. Numerous as these are, they are not nearly as varied as are the recent rodents of Wyoming. They are still primitive, just beginning to specialize in various directions, and all are more or less squirrel-like,—for squirrels, despite a few specializations, are about the most primitive of rodents surviving today and therefore most like these ancestral forms.

Passing giants

The largest and most impressive animals are the uintatheres, almost as large as elephants and elephant-like in their bodies but with very different heads, elongate and provided with three pairs of blunt, horn-like protuberances. Although they are herbivores, they have great saber-like canine teeth and use these to fight, not to kill prey. The fate of the dinosaurs is sufficient warning that size is not adequate insurance of survival. Indeed, these grotesque uintatheres are stupid survivors of the archaic fauna and they are to die out by the end of the Eocene.

Other archaic herbivorous survivors are condylarths, so varied in the Paleocene but now reduced to one kind which is, nevertheless, abundant, and taeniodonts, strange misfits that we saw at the beginning of the Paleocene. Both these groups, like the uintatheres, are destined not to survive the Eocene.

But there are others,—more varied and more numerous herbivores of modernized groups, Eocene invaders prophetic of the future. Among these are ancestral horses, Orohippus, differing little from its immediate ancestor Eohippus. Rhinoceroses are particularly common and there are many different sorts. Ancestral tapirs also occur. There are many titanotheres, odd-toed allies of horses and rhinoceroses and therefore modernized or progressive. They evolved more rapidly to a maximum and became extinct in the next epoch, the Oligocene. Even among the modernized groups that invaded in the Eocene there were many aberrant side lines that do not survive today.

The even-toed hoofed mammals, later dominant among all herbivores, are present in this middle Eocene fauna but are still rare. As yet only a few occur, rather small and too primitive to describe in terms of recent animals. Later their evolution seems to have speeded up and they passed the odd-toed forms, giving rise to such diverse creatures as pigs, hippopotamuses, camels, deer, antelopes, sheep, cows, and many others.

Flesh-eaters largely archaic

What of the flesh-eaters that preyed on all these herbivores? Here it is curious to note that the archaic types are still dominant. Varied creodonts, much like those of the Paleocene but in some cases swifter or more powerful, have developed from Paleocene ancestors without being replaced by invading modernized types. Some, indeed, are relatively advanced but the most potent invaders, of the cat, dog, and weasel families, had not yet made their way into North America. When they did, in the next epoch, the creodonts did not long survive the competition.

Perhaps the greatest popular interest is attracted by the presence of numerous primates, for this group of mammals includes the monkeys, apes, and man. None of these higher types, not even one as high as a monkey, has yet appeared in the middle Eocene; but lower primates are common, especially primitive lemurs. The lemurs, some of which still survive in the warmer parts of the Old World, have monkey-like hands, feet, and tails, but most of them have long, fox-like faces instead of the short, flattened faces so typical of monkeys—and of man, for that matter. (Our naked, smashed-in snouts perhaps look quite disgusting to a lemur.) The primate invasion started well back in the Paleocene, but the commonest middle Eocene type, a fairly typical primitive lemur called Notharctus, is of a more modern stock that invaded with Eohippus at the beginning of the Eocene. For some reason primates did not do very well in North America, where only a few survived the Eocene and none the next epoch, the Oligocene. That they survived abundantly elsewhere in the world is history.

The Great Invasion occurred almost simultaneously in Europe and North America and, as already mentioned, its source is not clear, although a number of students think that the main source, at least, was somewhere in Asia. Now it has been found that essentially the same invasion occurred in South America at a very much later date and under circumstances that permit its being followed from start to finish in considerable detail. This clear example helps to support the theory of an Eocene invasion in North America and, by analogy, to fill in some of the interpretive gaps left by incomplete factual knowledge of that earlier event.

This is what happened: the great Mesozoic dinosaurs and other -saurs also disappeared in South America at the Great Dying Time, and the Cenozoic started there, as in North America, with the appearance of the varied archaic mammals of the Paleocene. Then South America was isolated by the sea and it became an island continent. The modernized Eocene invaders of North America could not reach South America, and while the archaic fauna was fighting a losing struggle in the north, it had no competition (outside its own ranks) in the south and continued to flourish there. It evolved, too, of course, but the South American fauna was essentially archaic almost to the end of the Pliocene—a mere one or two million years ago—which was long after the great majority of archaic mammals had died out in the north.

Then the Isthmus of Panama rose. The modernized mammals of North America, evolved now into such familiar forms as foxes, raccoons, bears, wild cats, peccaries, deer, horses, and tapirs, invaded South America over this land route. In the ensuing bitter struggle a few of the archaic forms, like the armadillos, managed to survive and even to get a foothold in North America, but almost all of them became extinct and were replaced by the modernized mammals of northern origin. It was the Eocene struggle over again, long delayed by the accident that South America was an island in the Eocene and for long after.

Issued under the direction of the
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Roy W. Miner, *Chairman*

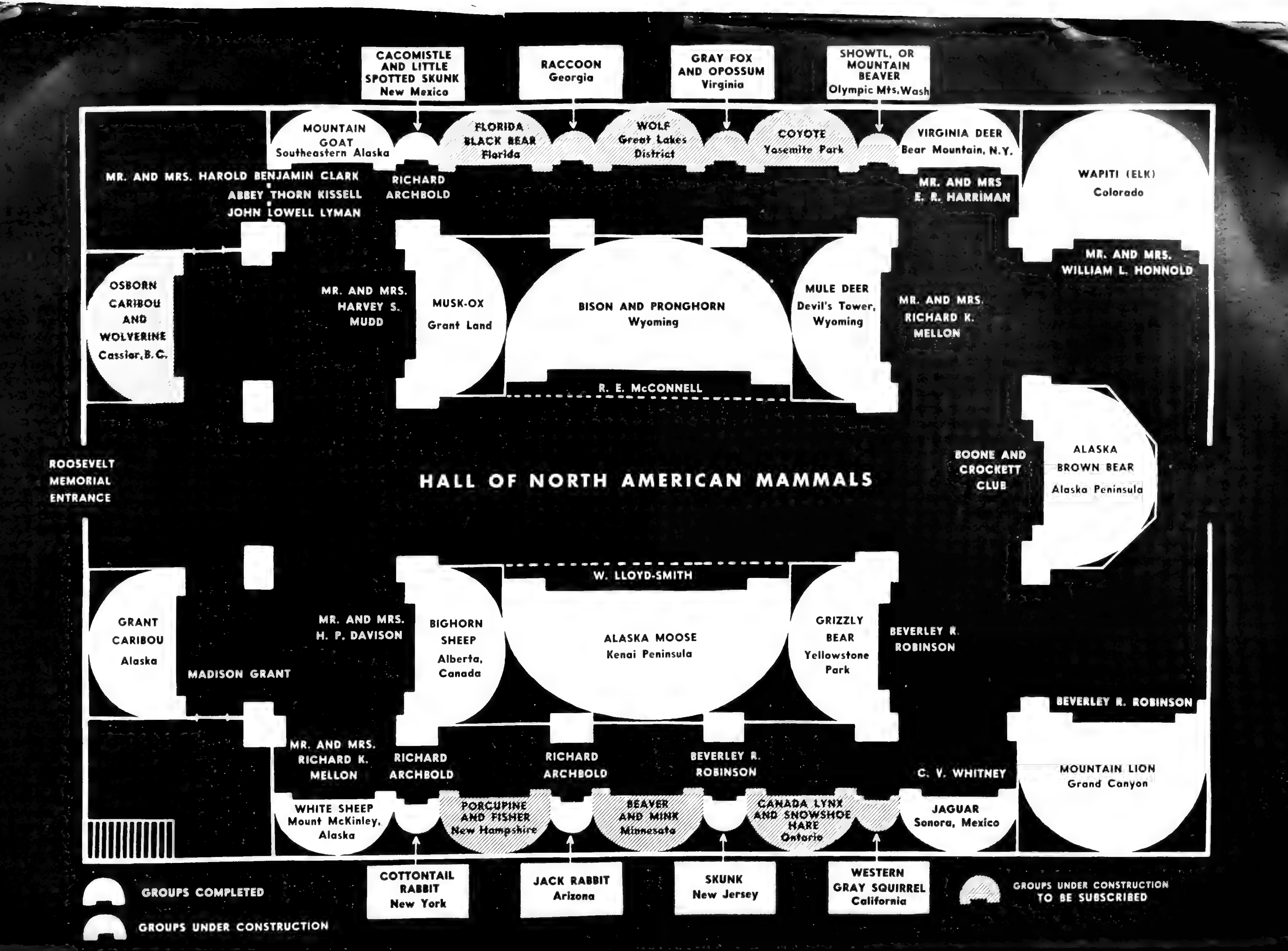
THE HALL OF NORTH AMERICAN MAMMALS

By HAROLD E. ANTHONY

THE AMERICAN MUSEUM OF NATURAL HISTORY

Issued under the direction of the
Committee on Popular Publications
Roy W. Miner, *Chairman*

With the generous support and able cooperation of the many individuals whose names appear on these pages the fine exhibits in this new Hall have been made possible.


HALL OF NORTH AMERICAN MAMMALS
CACOMISTLE AND LITTLE SPOTTED SKUNK New Mexico
RACCOON Georgia
GRAY FOX AND OPOSSUM Virginia
SHOWTL, OR MOUNTAIN BEAVER Olympic Mts. Wash
MOUNTAIN GOAT Southeastern Alaska
FLORIDA BLACK BEAR Florida
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MR. MADISON GRANT
Grant Caribou Group

MR. and MRS. E. R. HARRIMAN
Virginia Deer Group

MR. and MRS. WILLIAM L. HONNOLD
Wapiti Group

MISS ABBEY THORN KISSELL
Mountain Goat Group

MR. WILTON LLOYD-SMITH
Alaska Moose Group

MR. JOHN LOWELL LYMAN
Mountain Goat Group

MR. and MRS. R. E. McCONNELL
Bison and Pronghorn Group

MR. and MRS. RICHARD K. MELLON
White Sheep Group
Mule Deer Group

MR. and MRS. HARVEY S. MUDD
Musk-ox Group

MR. BEVERLEY R. ROBINSON
Grizzly Bear Group
Mountain Lion Group
Skunk Group

MR. C. V. WHITNEY
Jaguar Group

In addition to the groups donated, contributions have been received for the development of the wall treatment in the hall and for various expenditures not to be classified as costs of individual exhibits.

Credit should also be given to Colonel Francis T. Colby who collected specimens and accessories for the Alaska Brown Bear Group; to Mr. Wilton Lloyd-Smith for collecting specimens and accessories for the Grant Caribou Group; and to Dr. Henry M. Beck who donated the world's record horns for the Bighorn Sheep Group.

The floor plan shows the hall with the construction as it existed on Members Day, April 8, 1942.

SPECIAL ADVISORY COMMITTEE HALL OF NORTH AMERICAN MAMMALS

ROBERT EARLL McCONNELL, *Chairman*

CHILDS FRICK

DOUGLAS BURDEN

BEVERLEY R. ROBINSON

E. ROLAND HARRIMAN

H. P. DAVISON

MALCOLM P. ALDRICH

H. B. CLARK

RICHARD K. MELLON

HAROLD E. ANTHONY

JAMES L. CLARK

THE HALL OF NORTH AMERICAN MAMMALS

This panoramic exhibit of the animals of our continent in their natural settings embodies the latest and most progressive principles in scientific display.

Beginning some 30 years ago, a new ideal was envisioned in museum exhibiting. This ideal aspired to achieve new educational purposes through the realistic portrayal of wildlife in scenes of artistic beauty. Its realization depended upon the development of an elaborate new technique, and its watchwords have been truth, beauty, and faith in the value of Nature's lessons to man.

Many of the artists who helped to develop the method have also contributed their talents to the creation of this hall, which is thus a monument to their collective efforts and a climax in the evolution of a unique art. In admiration of its present and future implications, The American Museum extends sincere tribute to their names.

ART AND TECHNICAL DIRECTION

James L. Clark
Albert E. Butler

SCIENTIFIC DIRECTION

Harold E. Anthony

ON THE PAINTING OF BACKGROUNDS

JAMES PERRY WILSON	Grizzly Bear Bison and Pronghorn Wapiti (Elk) Jaguar
FRANCIS LEE JAQUES	Musk-ox
BELLMORE BROWNE GEORGE BROWNE assisting	Alaska Brown Bear White Sheep Bighorn Sheep Grant Caribou Osborn Caribou
CHARLES S. CHAPMAN	Mountain Lion
CARL RUNGIUS	Alaska Moose
JOSEPH M. GUERRY	Mountain Goat
FRED SCHERER	Virginia Deer Assisting on Bison and Pronghorn

ON THE MOUNTING OF ANIMALS

ROBERT H. ROCKWELL	Alaska Moose White Sheep Bighorn Sheep Grant Caribou Wapiti (Elk) Bison and Pronghorn Osborn Caribou Musk-ox Alaska Brown Bear
GARDELL D. CHRISTENSEN	Mountain Goat Grizzly Bear Virginia Deer Osborn Caribou Mountain Lion
GEORGE ADAMS	Mountain Lion Jack Rabbit Jaguar

ON THE BUILDING OF THE FOREGROUNDS

GEORGE E. PETERSEN	Wapiti (Elk) Grizzly Bear
G. FREDERICK MASON	White Sheep Mountain Lion Alaska Moose Musk-ox Alaska Brown Bear Wapiti (Elk) Grant Caribou Osborn Caribou Bison and Pronghorn Bighorn Sheep
JOSEPH M. GUERRY	Mountain Goat Alaska Brown Bear Bighorn Sheep
PAUL M. WRIGHT	Jaguar Bighorn Sheep
CHARLES B. TORNELL	Bison and Pronghorn Wapiti (Elk) Bighorn Sheep
BERNARD F. CHAPMAN	Grizzly Bear
RAYMOND H. DELUCIA	Mountain Lion Grizzly Bear Bighorn Sheep Jaguar
JAMES CARMEL	Alaska Moose

Since the realistic effect of these displays depends to a great extent on special techniques in illumination, particular credit is due the Museum's departments of Construction and Lighting.

THE NEW HALL OF NORTH AMERICAN MAMMALS BRINGS THE WILDLIFE OF OUR CONTINENT TO NEW YORK CITY

By HAROLD E. ANTHONY

THE AMERICAN MUSEUM OF NATURAL HISTORY

GUIDE LEAFLET SERIES No. 111

Reprinted from Natural History, Volume XLIX, No. 4, April 1942

The American Museum of Natural History PRESENTS

A GRAND

(Below) One of the most difficult animals to see in the wild, the cougar or mountain lion is displayed in the new hall with dramatic realism, amid the spacious grandeur of the Grand Canyon

From a Kodachrome by Thane Bierwert

TOUR OF NORTH AMERICA

As on a magic carpet, the city-dweller can view the wildlife of our continent from Mexico to the Arctic in the new Hall of North American Mammals

By HAROLD E. ANTHONY

Curator, Department of Mammals,
The American Museum of Natural History

THE splendid animals that are native to our continent, the scenic wonders that form their natural background in the wild, and the valuable lessons that can be learned from Nature, particularly in the conservation of our national resources —all these make the new Hall of North American Mammals a most important addition to the world-embracing exhibits in the American Museum of Natural History.

A hall depicting the life of our own continent had long been needed. In comparison with the modern halls devoted to African and Asiatic wildlife, our exhibits on North America were shabby and inadequate. The interest in our own North American fauna demanded that we do as well by the natives as by the aliens. The plan was set in motion, and eighteen separate expeditions, ranging from Mexico to Ellesmere Land north of Baffin Island and from the Atlantic Coast to the Pacific, have contributed to its realization.*

Embracing the expanse of North America thus covered, the new hall will bring to New York an impressive series of vistas into the best of primeval North America. Each animal group is an attempt to portray one or more species of mammal in an outstanding scene from the great outdoors. Many of these settings, such as Yellowstone Park, are favorite places of the tourist—regions selected by the government as National Parks because of their unique scenic and environmental values. Others are off the well-traveled routes. Mountain, desert, and arctic tundra, woodland and prairie—all types of geographic environment are represented in this comprehensive series of exhibits.

The selection of animals to go into the Hall has called for the most careful consideration. Animals having the greatest interest to the largest number of visitors have been given the most important positions. The hall has 29 alcoves, some of them very large. While the list of mammals in North America is a long one and no hall could show them all, even the lesser animals are properly represented in the smaller display groups. Whereas Akeley African Hall has a main hall and a balcony to devote to its exhibits, North American Hall achieves a practically equivalent display on one floor, as will be noted on the sketch plan of the groups.

This new hall is more than a hall of North American mammals. It is a hall of North American geography in a broad sense, a hall of North American ecology, with botany and all of the other environmental factors receiving the utmost attention. In planning the Mountain Lion Group, for example, the setting had to be one where this large cat was perfectly at home, a place where he belonged. The locality selected is the Grand Canyon. The lions themselves in the group are the obvious center of interest for the visitor; but they are only a single element out of many contained in the display. Beyond the lions, as far as the eye can see, stretches the breath-taking grandeur of the Grand Canyon, with the San Francisco Mountains in the distance, a spectacle unmatched anywhere in the world. It has been truthfully stated that no painting can do justice to the Grand Canyon. But a person in New York cannot see the Canyon itself, and this group is by all odds the next-best thing to being on the North Rim in person.

The casual visitor views the background in terms of enjoyment and entertainment, but a geologist sees in it a marvelous example of stratigraphy and of erosion on a stupendous scale. A student of botany or ecology—the science of plants, animals, and environment in their relation to each other—sees other things. He sees the flower known as the cliff rose growing out of the rock in the foreground, the cactus near at hand, the arid aspects of the landscape, and

* Credit for the new Hall of North American Mammals is shared by several organizations and many individuals. Without the financial support given by the City of New York and the interested co-operation of the Mayor, the Comptroller, and of the Commissioner of Parks, the American Museum would not have had the building and the physical equipment for the hall. A special advisory committee for the hall has been in existence since the plans were in the blueprint stage. The late Madison Grant was chairman of this body for some years. Since active construction was begun the committee has been as follows:

ROBERT EARLL McCONNELL, Chairman
CHILDS FRICK
DOUGLAS BURDEN
BEVERLEY R. ROBINSON
E. ROLAND HARRIMAN
H. P. DAVISON
MALCOLM P. ALDRICH
H. B. CLARK
RICHARD K. MELLON
HAROLD E. ANTHONY
JAMES L. CLARK

the lack of any vegetation on many of the slopes, demonstrating that erosion of the land proceeds unabated when there is no ground cover to check it.

The new Hall of North American Mammals should appeal to all classes of visitors. To many the exhibits will be entertainment, which is certainly an important criterion for Museum exhibition. It is especially important during this period of world-wide turmoil, when the daily press and the radio continually impress one with man's destructive powers and when there are so few releases from the war psychology. Even in a war-mad world, the outdoor man knows that, at such times as he can escape the sphere of man's domination, he will find the sun still shining, the plants and trees still green or budded with promise, and the animal life still pursuing the same pattern of life as during times of peace. The finer things of Nature are immutable, and man will be the better for it if he can divest himself of his own interferences with the universe and get back to first principles. The habitat groups of North American mammals will offer a valuable refuge and an opportunity for eyes weary of city streets to enjoy a grand tour of the North American continent. For a while at least, the visitor can lose himself in communion with Nature. He will not find it difficult to forget the barriers of glass and wood. The life-like animals are poised for action, and the illusion is so successful that one has the impression of observing living animals in their natural homeland, at closer range than is often offered the naturalist in the field.

Children will see for the first time many of the animals of our continent. They will learn the simpler facts in the life history of the animals from visual observation of the group and from the accompanying label. Many of the scenic backgrounds would remain an unknown world to them, unless they came to the Museum. Adults in search of education will get more from the groups in measure as their individual backgrounds afford the basis for interpretation, and in the direction their curiosity leads them. The sportsman needs little beyond the immediate visual stimulation to grasp the meaning of an exhibit showing an animal he has hunted.

For many visitors, the educational value of a museum is more effective if it is not too obvious and if it is sugar-coated. If exhibits are openly displayed as lessons, many visitors will turn aside because they are not in the mood. But even the individual frankly in search of entertainment is educated unconsciously if the exhibit is planned along the proper lines. Students or classes using the Museum for source material will find that the new hall offers great opportunities.

A great deal of special information can be given in guide leaflets. It is impossible to set forth on a label all the facts covering one of these habitat groups. Labels must be restricted to a size and prominence that will not compete with the group itself and act as a distracting influence in the hall. The beauty and the illusion of reality are lost if large, conspicuous labels catch the eye at every turn. They are like briliant signboards in the wilderness, and few would come to a museum on the primary appeal of labels. But the visitor can keep the guide leaflet to read at his leisure, if he does not care to do so at the side of the group while he is in the Museum. An outline or a syllabus will probably best serve the class in nature study, in ecology, or in geology. Such an outline would point out the salient facts as demonstrated in each group. It might suggest the best order in which to study the groups and refer to supplementary information that can be derived from other halls in the Museum and from collateral reading. The education and inspiration are there for those who seek them, for in these exhibits the visitor "Finds tongues in trees, books in the running brooks, sermons in stones."

The sex and age of the animals making up a group, as well as the posing of them, must be carefully planned in advance. A popular idea is to show male, female, and young, thus stressing the family associations. An invariable adherence to this pattern, however, would become monotonous and would prevent the display of much more interesting attributes. For example, male deer are most impressive in the fall of the year when their antlers are at their prime. At this season the young, on the other hand, are no longer tiny, spotted creatures; hence a fall group of buck, doe, and spotted fawn would be a biological misfit. This illustrates in a simple way a multitude of considerations, which extend to include flowers and other seasonal vegetation in an authentic group. Or again, among mountain sheep the rams with their massive horns are so much more eye-arresting than the ewes that they draw the limelight on any stage they occupy. Furthermore, during a large part of the year the big rams range in small groups apart from the ewes, so that it is good natural history plus good showmanship to plan a sheep group with the rams monopolizing the attention. Mountain sheep live in precipitous rugged topography, and as a foil against the mighty mountain background the powerful and majestic rams get first call on the foreground. The composition of the various groups can be studied, along with the explanations accompanying them, in the pictorial section following this article.

Work is far advanced on five other large groups, and a beginning has been made on still others. Since the construction of such a large hall is an operation

requiring years, the committee in charge decided to open it in advance in order to get the maximum use of the results. This will also enable visitors to see something of the groups under construction. To most people the actual creation of a group—the painting of the background, the assembling of the accessory material, the composing of the group itself—are matters of great interest. And the appreciation of the end product is increased if one has noted the careful and laborious steps by which it has been achieved.

None of the smaller groups have been completed, but these will round out the full picture of the animal life of our continent. And let no one think that because they are small they are of minor consequence. With the larger mammals, which are the game animals, the time of the year must invariably be fall, winter, or early spring. At any other time than the period of cold weather the pelage will be shabby or antlers will be unprime or missing completely. In the case of the smaller mammals these factors are not disturbing, and one can select a season when Nature has furnished a more gracious environment. Whereas a large mammal like the bison wears a worn or shedding coat in early summer, a skunk or a jack rabbit makes an altogether satisfactory exhibit at that season. Consequently, the smaller groups can go around the calendar and will provide the hall with spring and summer barkgrounds.

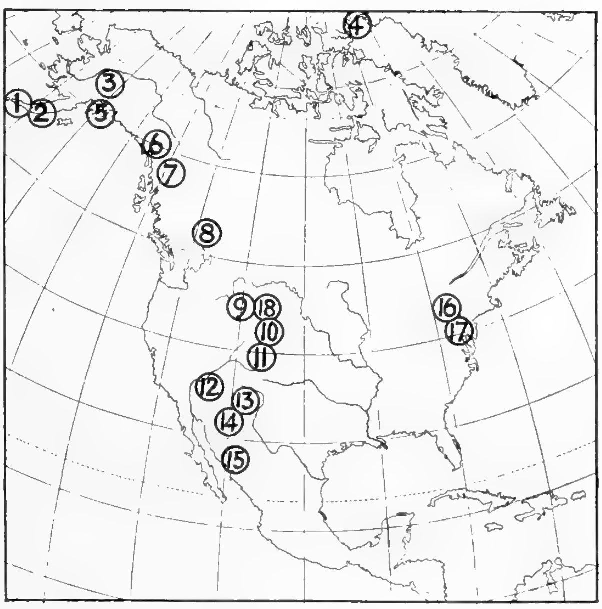
The average person who is familiar with the North American mammals of today does not realize the great variety of animal life from which they are survivors. Many mammals which now exist only in the eastern hemisphere had representatives in North or South America some thousands of years ago in the Pleistocene, or Ice Age. Sportsmen who marvel at the great variety of animals living in Africa today are interested to learn that our North American fauna of geologic yesterday was equally extensive and that many species have been lost with the advent of the Recent epoch. To give a brief survey of the predecessors of our existing North American mammal fauna, it is planned to have introductory exhibits at the entrance to North American Hall. These exhibits will show a few of the absentee members and give the visitor a better insight into the former riches of our continent.

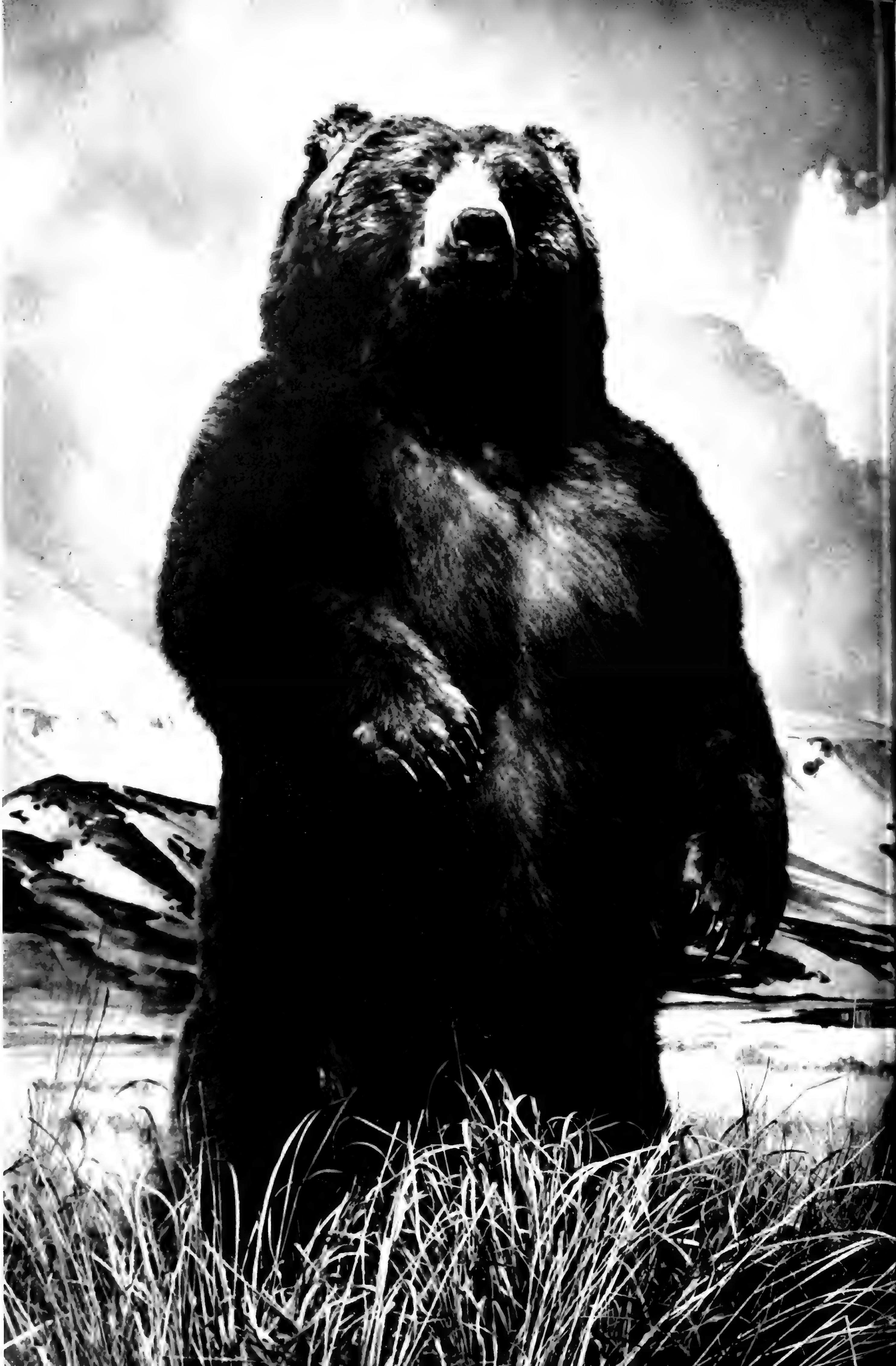
Other features of the hall which are planned but which will not be evident at the opening are the charts, maps, and diagrams which will be placed upon such of the walls as permit. These two-dimensional exhibits will cover a multitude of subjects having a direct bearing upon the distribution, evolution, and significance of the mammals on display. No class of animals can be discussed in the fullest terms if held apart from such fundamental factors as vegetation, climate, and topography. To understand the causes which make mammals look and act as they do, one must know something of their environment and of the forces which work upon all living matter. Many of the casual relations in this complex problem are yet to be discovered or formulated, but there are many factors which by association appear to have profound effects. Information of the latter character, such as distribution of forests, rainfall, desert, etc., will be given in chart form in some of these wall exhibits. The evolution of special structures or adaptations, such as the development of antlers through the life history of an animal, will also lend themselves to graphic display; and the rate of increase or decrease of various animals will illustrate many principles closely connected with the conservation of wildlife.

The pages following this article will show the reader something of the wide variety of informative and artistic material which makes the hall of North American mammals the foremost exhibit of its kind in the world.

The work of eighteen expeditions is embodied in the displays in the new hall, and others will follow.

1. ALASKA BROWN BEAR
2. GRANT CARIBOU
3. WHITE SHEEP
4. MUSK-OX
5. MOOSE
6. MOUNTAIN GOAT
7. OSBORN CARIBOU
8. BIGHORN SHEEP
9. GRIZZLY BEAR
10. MULE DEER
11. WAPITI (ELK)
12. MOUNTAIN LION
13. CACOMISTLE & SPOTTED SKUNK
14. JACK RABBIT
15. JAGUAR
16. COTTONTAIL RABBIT
17. VIRGINIA DEER
18. BISON & PRONGHORN





Alaska Brown Bear

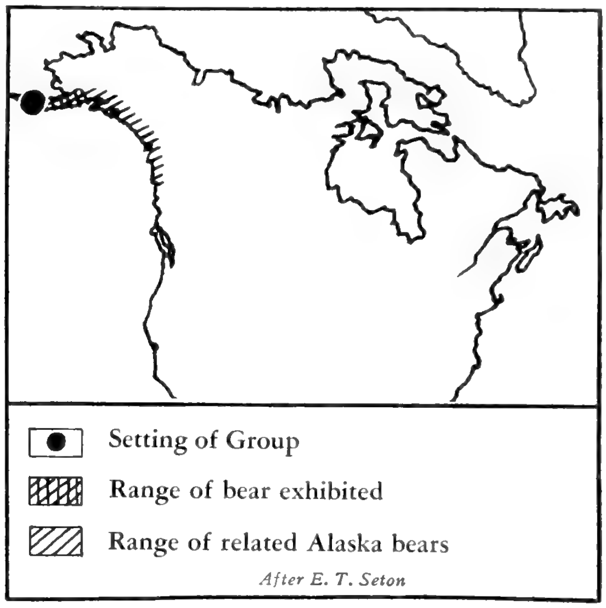
Ursus gyas Merriam

THIS huge bear is the first figure you will see upon entering the new Hall of North American Mammals. Its gigantic form, viewed against a background of towering Alaskan peaks, staggers the imagination. The Alaska Brown Bear sometimes weighs over 1600 pounds and is the world's largest carnivore. In ferocity, however, it does not have the reputation of the grizzly. Its great size is probably related to its abundant food supply. Hoards of salmon *(foreground, below)* run all summer, and the plentiful vegetable food of late spring and late fall is supplemented by mice, marmots, and carrion.

The brown bear goes into hibernation high on mountain slopes, sometimes as late as November, and emerges in April or May. These two males have just come down to the warm lowlands where there is more food. The cubs remain with the mother for about two years and apparently take six or seven years to reach full size.

By the stream at right is seen a Pacific land otter, found from Oregon to Alaska. It swims in a series of leaps and dives, and likes to play on snow or clay "slides," down which it coasts on its chest headfirst into the water.

The volcanic mountainous background of this wonderful scene on the Alaska Peninsula dramatically illustrates the scooping action of glaciers and snow fields in producing U-shaped valleys and cup-like cirques.



The descriptive text accompanying these displays was assembled by NATURAL HISTORY Magazine from information prepared for the hall by George G. Goodwin, G. H. H. Tate, T. Donald Carter, and John Eric Hill

AMNH photos by Thane Bierwert

Moose

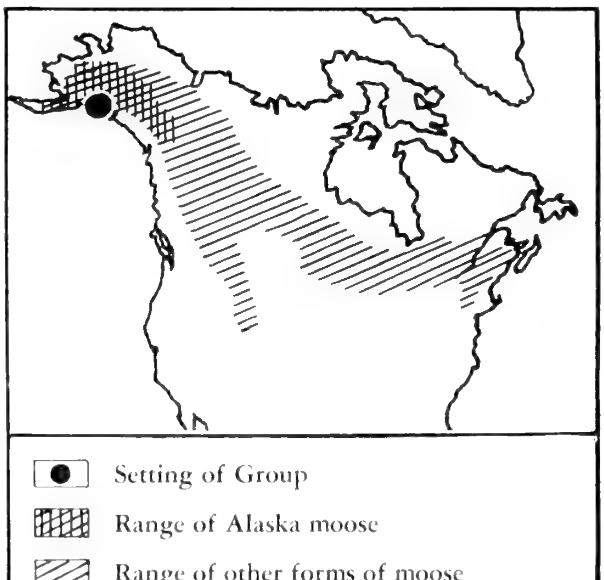
Alces gigas

MOOSE are the largest and grandest of the deer family. In the Kenai Peninsula and neighboring regions of Alaska, they reach their greatest size both in stature and in horn development. The antlers on the bull on the right in this group represent the world's record in size and have a spread of $77\frac{5}{8}$ inches. New antlers are grown each year; the females have none. Males stand as high as six and one-half feet at the shoulders and weigh as much as 1400 pounds. The females are only about three-quarters as large as the males. Moose are found in nothern Europe, Asia, and North America.

During the mating season terrific battles occur when two rivals encounter each other, as shown above. The noise of a moose crashing through brush and fallen timber, pausing occasionally to thrash at the shrubbery with his antlers, gives one the impression that nothing can stop his massive advance.

Aside from man, the chief enemy of the moose is the wolf. The calves sometimes fall prey to bear and mountain lion.

Moose are forest-loving animals and prefer country with numerous lakes. In summer they enjoy wading into these lakes for protection from flies and mosquitoes and to feed on water plants. Moose are chiefly browsers, feeding on the bark, twigs, and leaves of maples, birches, alders, and willows.



After E. T. Seton

AMNH photo by C. H. Coles and R. E. Logan

Bison and Pronghorn

Bison bison bison and
Antilocapra americana americana

THE photograph below is of a miniature model and illustrates the painstaking care with which every step is planned in the construction of a group. This exhibit, now nearly completed, faces the Moose Group along one side of the long central corridor of the Hall of North American Mammals. The scene is a historic one in Wyoming near where the famous Overland Trail crossed the North Platte River. It shows the well-known American bison, or buffalo, which once roamed over our Great Plains in countless millions, and the graceful pronghorn. The latter is the only antelope in the world with branched or pronged horns.

AMNH photo by Julius Kirschner

AMNH photo by C. H. Coles

White Sheep

Ovis dalli **Nelson**

THE massive curling horns tell you that these are mountain sheep. Their pure white color indicates that they come from the North. Throughout Alaska, the coat of this animal is all white except for an occasional brownish stain. Farther south, in the Yukon, the coat darkens, until finally in northern British Columbia a very dark sheep is found. This sheep is the subspecies known as *stonei*, or Stone's sheep.

These animals are expert mountain climbers and are not found away from steep and broken country. They are extremely sure-footed and climb up and down precipitous slopes where a man could not hope to pass. The sound of dislodged stone may be the first notice that they are above, though the adult may indicate its presence by a snort, or the kid by a shrill blat. When frightened, their tendency is to climb to the most inaccessible cliffs for protection. They have keen vision and depend more upon their eyes than upon their ears or nose to detect an enemy.

White sheep live only above timber line and spend their lives in a limited area, descending from higher altitudes only when forced down by snows. They are active throughout the year and may be seen at any hour of the day, but they often lie down to rest or take the sun after feeding in the early morning, to resume grazing only late in the day.

Although these animals are true sheep, their coat is hairy and not woolly. The horns of the females are smaller.

A SUPERB coat of heavy hair protects the musk-ox from the extreme winter temperatures of its arctic home, and the animal is able to secure food by pawing away the snow from the mosses and lichens on which it feeds. Unlike the Barren Ground caribou, which migrates north and south with the seasons, the musk-ox remains in the far north throughout the year.

In the Pleistocene or Ice Age, musk-oxen ranged over most of Europe, Asia, and what is now United States, but they vanished from these regions before historic times. Even in the past hundred years or so, their remaining realm in arctic America has become definitely smaller. Man is the musk-ox's worst enemy and is chiefly responsible for this.

Musk-oxen are found in herds of from ten to 30, formerly in much larger ones. When attacked, the herd forms a circle with the calves in the center, thus presenting a formidable phalanx to wolves—but not to men with guns.

The shaggy coat makes it easy to overestimate the weight of a musk-ox, but bulls do weigh 600 pounds or more and measure five feet at the shoulders. One is apt to think of musk-oxen as a sort of cattle, but actually they are more closely related to sheep and goats. Their nearest relative is the Himalayan takin. Usually the cow gives birth to a single calf, late in April or May.

Musk-ox

Ovibos moschatus Zimmerman

AMNH photos by Thane Bierwert

Setting of White Sheep Group

Range of white sheep

Range of the blackish race of white sheep

Setting of Musk-ox Group

Range of musk-ox

After E. T. Seton

AMNH photos by Thane Bierwert

Mountain Goat

Oreamnos americanus Blainville

THE mountain goat is not a true goat but belongs to the goat antelopes, or Rupicaprinae, which includes also the chamois, serow, and goral of the Old World. His home is on the high, sheer peaks of the mountains, far above timber line. His outstanding accomplishment is his marvelous climbing ability. In this he even surpasses the mountain sheep. Traveling along precarious cliffs where other animals dare not follow, he is safe from his natural enemies,—wolves, bears, and mountain lions. The eagle may occasionally take a kid but only when it is left unprotected by its mother.

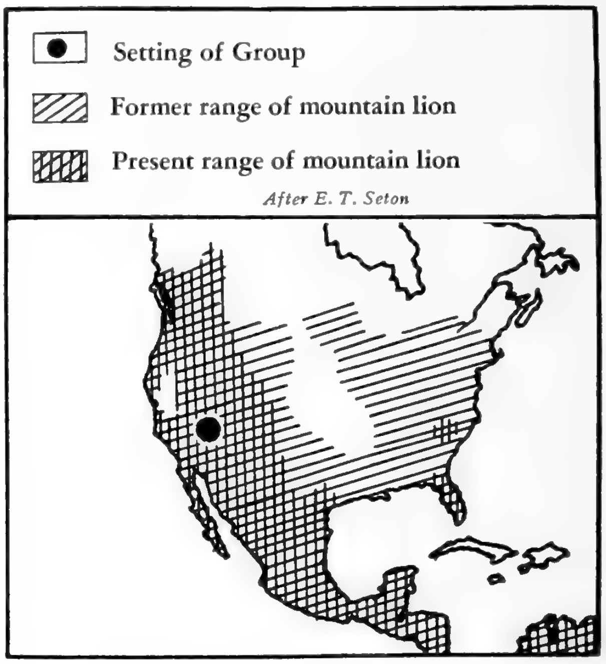
The kids are born in April or May, generally one to a mother but sometimes two. Within a few days after birth they are able to follow their dams.

The food of the mountain goat consists of mosses, lichens, bushes, and grass. He does not descend into the lower levels during the winter, as do the sheep, but finds sheltered spots among the rocks for protection against storms. The crag represented above overlooks Alaska's Sawyer Glacier.

After E. T. Seton

Mountain Lion

Felis concolor Linnaeus



In spite of his common names, which might indicate such a kinship, the mountain lion, cougar, puma, or "panther" has no close relatives in Europe, Asia, Africa, or Australia.

In the West the mountain lion prefers rough mountainous country, but it was formerly at home throughout the forests and rocky regions wherever deer occurred, from Canada to Patagonia.

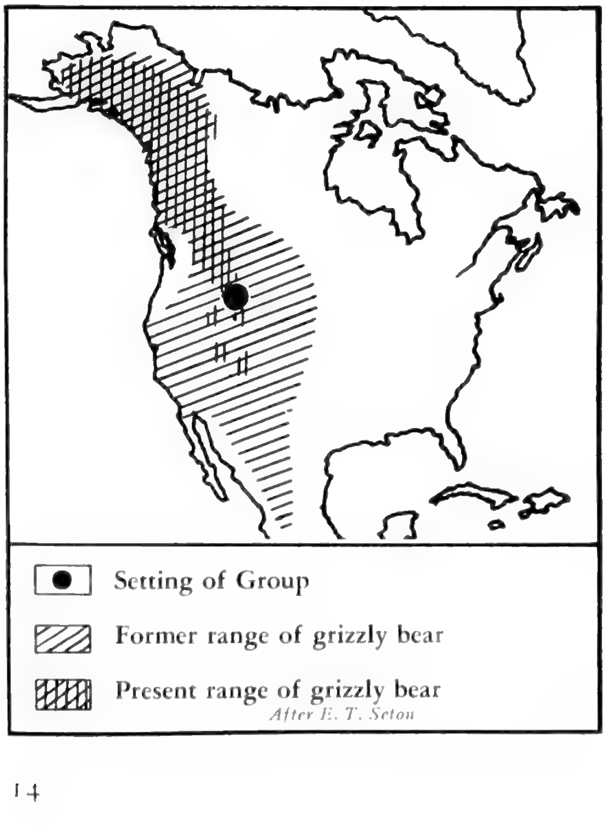
Early settlers considered the big cat dangerous, but few attacks on mankind were recorded, and only a starving or cornered cougar is to be feared. They are shy and are rarely seen, even when common. Individuals will, however, follow a man for miles and prowl around camp, apparently from pure curiosity. They are readily tamed, especially when young, and remain docile and playful.

Cougars are usually found in pairs except for a short time after the birth of the young.

The background is the Grand Canyon, whose rock walls present the most complete record of earth history found anywhere in the world.

Grizzly Bear

Ursus horribilis Ord



The name "grizzly" was given to this bear because of its unusual coloring. The word "grisly," meaning terrible, gruesome, or grim, was applied later but was evidently in the mind of Ord when he gave the grizzly the scientific name *horribilis*.

The grizzly bear is the most formidable and ferocious animal in North America, and yet, according to the best authorities, it rarely attacks man unless provoked. Its mentality is far inferior to that of the dog or wolf, but its powers of scent and hearing are highly developed. The favorite range of the grizzly is high rolling uplands, with rocky ridges and densely wooded thickets. Here it finds abundant food, consisting of roots, berries, nuts, insects, reptiles, fish, birds, eggs, and mammals ranging from mice to cattle. The young are born in the mother's winter den and are exceedingly small at birth. The second winter they den up again with the mother, but after that are able to shift for themselves.

Grizzly bears seem to communicate by a sort of signpost language. The bear bites a trunk high up, tearing the bark open crosswise, and often leaves five raking claw marks.

AMNH photo b[illegible] Thane B[illegible]

AMNH photo b[illegible] C. H. C[illegible]

AMNH photo by Thane Bierwert

Grant Caribou

Rangifer arcticus granti **Allen**

THE animals in this group are a variety of Barren Ground caribou that are restricted to the Alaska Peninsula; thus they belong to a group having a wide distribution over the treeless tundra of the circumpolar regions. Caribou are the only deer in North America whose females have antlers. Both sexes shed their antlers annually.

The winter coat of this animal, with its thick growth of air-filled hairs, is weatherproof and affords fine protection from the cold. The large, spreading hoofs are suited for travel over the soft muskeg in summer and the deep winter snows where other hoofed animals would sink and flounder.

The life of the northern caribou is one of continuous travel. It summers on the tundra along the Arctic coast and migrates south for the winter months in immense herds, to the border of the forest belt. In the summer its food is grass and in the winter, lichens. The mating season is October, and the young are born in June.

The most formidable enemy of this caribou is the great white wolf, but bear, wolverine, and other predatory animals take a limited toll. During the summer months insects are a great menace to all caribou.

The caribou is an important source of subsistence to the people of the arctic regions, both in food and clothing.

Big-horn Sheep

Ovis canadensis Shaw

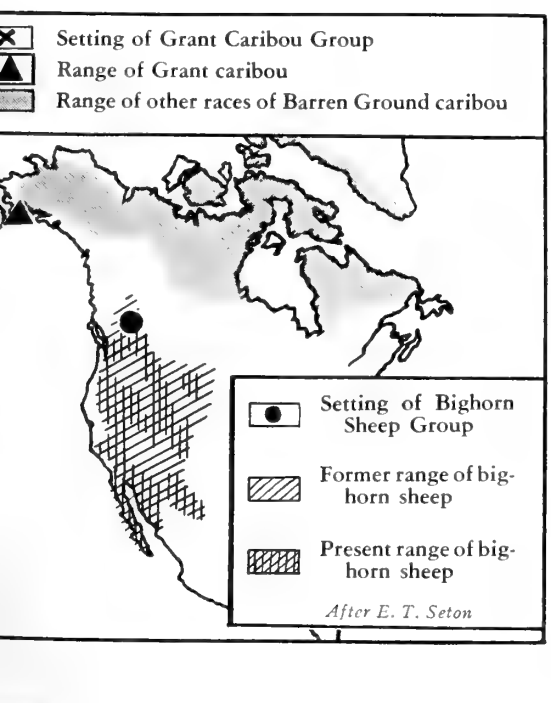
AMNH photo by Thane Bierwert

THE most coveted prize of the American big-game hunter, the bighorn sheep, inhabits the rugged mountains far above tree line and only descends when forced down by deep snow. Throughout most of the year, the older rams go about in small parties, keeping to themselves, while the ewes, lambs, and young rams form separate flocks. In late November the rams join the ewes, but after the breeding season they return to their former mode of life. The lambs are born in late May or June.

Besides man, the bighorn has many enemies. Coyotes, wolves, bears, mountain lions, lynxes, wolverines, and eagles,—all prey on the lambs, and the larger carnivores all enjoy a meal of mutton.

The horns on the right-hand ram *(also above)* are the world's record—49½ inches along the curve—and were donated by Dr. Henry M. Beck.

The scene is Jasper National Park, Alberta, and shows Mt. Athabaska as seen from the slopes of Mt. Wilcox at about eight o'clock in the morning.



AMNH photo by C. H. Coles and Thane Bierwert

MAMMALS OF NORTH AMERICA

By T. Donald Carter

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MAMMALS
OF
NORTH AMERICA

By T. DONALD CARTER
Assistant Curator of Mammals

Science Guide No. 111
A Guide to the North American Mammal Hall

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The Grizzly Bear

Introduction

NORTH America can well be proud of its mammal fauna and also of the scenic beauty of its forests, plains, lakes and mountains. To bring these together where they can be viewed by thousands of people has been the ultimate aim of the new Hall of North American Mammals in the American Museum of Natural History, New York.

When this hall is completed, there will be twenty-nine animal groups, each depicting one of the more prominent mammals in its native habitat. The background scene or landscape for these groups has been chosen with two thoughts in mind: first, representation of a locality where the animal would naturally be found, and second, reproduction of a specific place of scenic or historic importance. The selected scenes are as diversified as possible in order to give the viewer a better understanding of the great differences in the natural character of our continent. Each group shows both the distinctive botanical and geological features of the area. Consequently these habitat groups appeal not only to the visitor interested in mammals, but to students of botany, geology and ecology as well.

The work on these groups begins in the field. Field personnel, generally consisting of an artist, an accessory man and a scientist, choose the site to be portrayed. A painting of the proposed site is made and numerous colored pictures are taken. Accessories which include plants, trees, and bushes are gathered. Paintings are made of the flowers, leaves and any other vegetation that is liable to fade or change color. Plaster casts of the foliage which may dry or shrivel are necessary, and some of these leaves and plants are brought back in formalin. Trees, logs and other objects characteristic of the spot are collected and cut into suitable lengths for shipping, to be again reconstructed in the Museum. Samples of the rocks are taken, and soil and debris to cover the foreground of the group are gathered. The animals are collected and numerous measurements are carefully taken. Casts may be made of the face or any part that may have some peculiarity. Series of photographs illustrating various physical and anatomical views of the animals are obtained. Then the animals are skinned, the skins salted and dried, and the skeletons removed and preserved.

Upon returning to the Museum, the first work toward the new group is the making of a small scale model. The background is painted using the field sketch as a guide. Small scale replicas of the trees, stumps, rocks and vegetation are made, as well as replicas of the animals themselves. It is in this model that the accessories and mammals are shifted about until the desired effect is obtained. When this has been accomplished, construction on the large group begins with the use of the model as a guide.

As with the model, the first step in producing the large group begins with painting the background. This task often requires several months. During this period, the foreground accessories are constructed. Everything that can be preserved, such as the hard parts of trees, bushes, grasses, reeds, and pine needles, are used after having been treated and painted. However, the more delicate leaves, flowers and other vegetation have to be reconstructed. These artificial accessories are usually produced from paper, celluloid, wax and cotton, or various plastic materials. Large rocks are made of plaster and painted and patterned after the original specimens brought in from the field. The mammal skins are mounted on a manikin which is an exact duplication of the skinless animal. The only part of the original animal in the finished mount are the skin and the hoofs, tusks, or horns. To lend a natural effect to the completed habitat group, a battery of lights is carefully installed to reproduce proper outdoor lighting conditions.

North America cannot boast of so many varieties of mammals as can Africa, but her fauna is varied and interesting. The Alaskan moose is the largest of the deer while the Alaskan brown bear is the largest land carnivore. Many North American mammals have counterparts in Asia, indicating that in the not-too-

distant past there was a land connection across Bering Strait. The Asiatic wapiti are so close to our American wapiti that they are classified by many scientists as subspecies. The same holds true with our Rocky Mountain sheep and the Kamchatka bighorn, the Asiatic elk and our moose, the reindeer and the caribou, and the brown bears of both continents. However, North America can boast of several animals as her very own, the most notable of which is the pronghorn. No near relative is found anywhere else in the world.

As is the case the world over, the smaller mammals far out number the larger more conspicuous ones, and it is unfortunate that there is not room in the Hall of North American Mammals to have them better represented.

One of the most common native mammals is the white-footed mouse, of the genus *Peromyscus*. This animal occurs throughout the continent as far north as there is timber. It has adapted itself to varying climates and over 150 forms are recognized. Field mice of the genus *Microtus* are also exceedingly common although their number fluctuates greatly from year to year. North America also contains numerous species of tree squirrels, chipmunks, ground squirrels and flying squirrels. Bats are common and vary in size from the hoary bat to the pipistrelle. The smallest of our mammals include the shrews, small insectivores which, although common, are seldom seen and are related to the ground moles, whose presence is indicated by their runways.

The only North American marsupial is the opossum, an animal which is working its way farther north each year.

No true wild pigs are found on our continent. The nearest relatives are the peccaries of the Southwest.

North America is noted for its many valuable fur bearers. It was in quest of these that the early explorers were constantly moving west. The beaver was once our most important fur bearer, but today the muskrat, mink, weasel, fox, marten, fisher, skunk, lynx, coyote, badger, raccoon, and otter contribute to our fur supply.

Two small group models at the entrance of the hall depict some of the larger mammals which roamed our continent during the Pleistocene Era, before the great glaciers moved down over the northern half of North America.

Mr. Perry Wilson Painting a background

The Grizzly Bear

Ursus horribilis Ord

Smaller than the Alaskan brown bear but with a more ferocious reputation, the grizzly bear is much better known to most people. The original range of the grizzly bear extended throughout the Rocky Mountain region from Alaska to central Mexico, and even extended out onto the prairies. Now it is rare within the borders of the United States, and only in the Yellowstone National Park is a wild grizzly likely to be observed. It is still found in the mountains of Alberta and British Columbia and is fairly common in some of the more remote sections of Alaska. Lewis and Clark, in their journals on their famous expedition in 1803-1806, gave us one of the first good descriptions of this bear. They encountered it a number of times and noted that it was a dangerous antagonist, greatly feared by the Indians.

Individual grizzlies differ both in size and color. Very light cream-colored individuals exist, while others may be a dark brown. A light and dark cub may be found in the same litter with a mother of a still different hue. The hairs of the coat are often tipped with gray or yellow, giving the animal one of its popular names, "Silver-tip." A number of races have been described, based chiefly on skull characters, but on account of individual variation in both color and skull formation the classification of these bears presents a difficult problem.

Adult grizzlies will seldom weigh more than 500 pounds and average about six feet in length. The females are generally smaller. Like all bears its sight is poor, but it has an acute sense of smell and depends upon the nose to warn it of danger.

The grizzly is not particular in regard to its food. It feeds upon grass, roots, berries, nuts and other vegetable matter, any mammals from mice to cattle, and is not adverse to carrion to appease its hunger. It is very fond of ground squirrels and marmots and will spend hours in digging a single individual from its burrow.

Like all bears in the north, the grizzly spends the winter months in a den. This den may be a cave in the rocks, a hole dug in a bank, or a shelter beneath the roots of a fallen tree. It is in this den that the cubs are born. Two generally constitute a litter, but there may be three or occasionally four. The cubs spend the summer in company with their mother and will often den up with her the following winter, for the mother grizzly has cubs only every second or third year. The cubs readily climb trees, but as they grow older their heavy weight and long claws prevent them from doing so.

The grizzly is undoubtedly the most formidable and ferocious animal in America but will seldom attack man unless provoked. Before the high powered rifle a grizzly was a beast to be feared. Modern firearms have changed this. The grizzlies prefer to keep out of the way of man, but a mother with cubs, or a wounded bear, is still a dangerous animal to encounter. There is an old saying that you should never take anything too much for granted with a grizzly, for you can never prophesy just what the bear will do.

The site of this group is the southern rim of the canyon of the Yellowstone near Artist point, about one mile below the falls.

The Alaskan Brown Bear

Ursus gyas (Merriam)

Extending along the Pacific coast from the Alaskan Peninsula to British Columbia are a series of islands, and it is on these islands and the adjacent mainland that the big brown bears of Alaska make their home. There is so much variance in the size and color of these bears that their classification is very difficult. Their color ranges from a very dark brown to a creamy white. The typical brown bears of the northern part of their range are easily distinguishable from the grizzlies by their larger size, their shorter, stouter, more curved claws and their uniform colored coat without any silver tipping. There are also dental differences. In the southern part of the range, bears exist which are difficult to place as they show characteristics of both the brown and the grizzly. For this reason it is now the custom to include both bears in one general group.

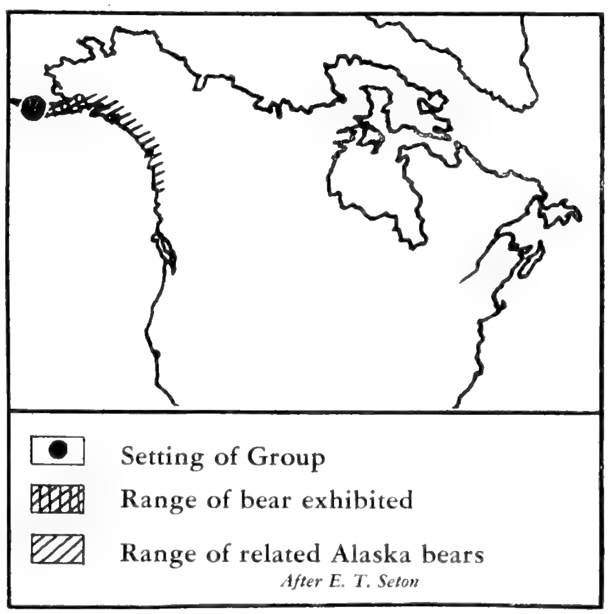
The largest forms of the brown bear are the Peninsular Bear (*Ursus gyas*), the species represented in the group, found on the Alaskan Peninsual and Unimak Island, and the Kodiak Bear (*Ursus middendorffi*), confined to that island. These bears may reach a total length of over nine feet from the tip of the nose to the end of the tail, while a stretched skin has measured over thirteen feet. Specimens have been recorded to have weighed over 1600 pounds. They are considered the largest existing carnivorous land mammals.

The young, which number from one to four, are born while the mother is in her winter den. As with other bears the cubs are very small at birth, weighing about a pound and a half, but by spring when the mother leaves the den the young are large enough to follow her about.

In the early spring, grass and roots as well as small mammals form much of the food of these bears. Later, the bears consume great quantities of berries. The salmon begin their run up the rivers to spawn in June, and from this time on the bears seek the rivers and turn to fishing for a living.

As with most bears the sight is poor, and they depend on their keen sense of smell for information. If suspicious they often rear up on their hind legs so as to obtain a better view over the vegetation.

Canoe Bay, Alaska Peninsula, is the location of this scene. The peaks in the background, known as the Aghileen Pinnacles, are of volcanic origin. The scooping action of glaciers and snow fields in producing U-shaped valleys and cup-like cirques is everywhere evident.



The American Black Bear

Euarctos americanus (Pallas)

The American black bear is truly a North American bear. It is found from the Atlantic to the Pacific coasts, from northern Alaska to central Mexico, and from the peaks and glaciers of the Rocky Mountains to the swamps and cane brakes of Georgia and Florida, wherever there is sufficient cover for its protection. It has disappeared from most of our plains states but is still found in many eastern states. Near New York it occurs in the Catskill and Adirondack Mountains, and it is common in certain sections of Pennsylvania, from whence an occasional stray wanders into New Jersey.

On account of its extensive range and varied habitat a number of races occur. The brown cinnamon bear of Wyoming and adjoining states, Emmon's bear (also known as the glacier bear or the blue bear), found near Mount Elias on the southern coast of Alaska, and the white Kermode's bear from the drainage of the Nass and Skeena rivers in western British Columbia are now all considered color phases of the black bear.

In the northern part of its range the black bear dens up during the winter months. In late January or early February the cubs are born. Twins seem to be the rule, but sometimes litters of one, three, or occasionally four are born. At birth a cub is only about eight inches long and weighs but ten ounces. It is an interesting fact that the young of the Canadian porcupine is larger at birth than is a black bear cub. However, the cubs grow rapidly and are able to follow their mother about when she leaves the den in the spring.

The food of the black bear consists of roots, nuts, fruit, ants and other insects, flesh and fish. Occasionally a black bear will turn stock killer but as a rule he is a desirable citizen. Where much persecuted he is one of the wariest of animals. On occasion one will be taken by surprise by berry pickers, for the black bear has a fondness for berries and knows where the best ones grow.

Unlike the grizzly, the adult black bear readily climbs and often ascends trees for the purpose of securing its food. In sections where bear are common the beech trees show scars of their claw marks. In the southeast the bears are fond of the fruit of the cabbage palm and will climb the trees, throw down the fruit clusters and then descend for their meal. The bear will pull out the central bud of this tree to feed on the tender heart.

The site of the Museum group is in the center of the Big Cypress Swamp in Collier County, Florida. The bear which is the Florida black bear (*Euarctos floridarius*), is shown as proceeding along one of the numerous trails when his way is disputed by a water moccasin or cotton-mouth lying in the path. The snake is giving its customary warning—a widely opened mouth showing the white interior—which gives this snake one of its common names. The bear is wisely deviating from the trail, leaving the snake in full possession. The large-leafed plant in the foreground is the fire-flag, the roots and stalks of which are sometimes eaten by this bear.

The Wolf

Canis lupus Linnaeus

Although the wolf formerly ranged over most of the North American continent, its predatory habits have caused it to be hunted and trapped by man until it is now a rare animal in most parts of the United States. East of the Mississippi River it is found only in northern Michigan and Wisconsin.

The wolves of North America have been divided into two main groups, the gray wolf (*Canis lupus*) of the north and west and the red wolf (*Canis niger*) of the southern states. The red wolf is now believed extinct east of the Mississippi River although on occasions it may cross this river into Mississippi. It is still

found in southern Missouri, the Ozark Mountains in Arkansas, very locally in Louisiana, Oklahoma and eastern Texas. At one time it was common in Florida and extended as far north as South Carolina. This eastern form of the red wolf was often found in the black phase which gave it its scientific name.

The color of wolves varies greatly. The predominating color is gray with black-tipped hairs, but in its many phases it may be any shade from black to white.

Wolves apparently mate for life, the father assisting in rearing the family. The size of the litter may vary from five to fourteen; seven is an average size. The home den is either a rocky cave, a burrow or a hollow log. Here the young remain until they are about three months old. From that time on they hunt with their parents. These family parties generally stay together throughout the winter.

Over much of the wolf's range deer form an important item in their food. In the Rocky Mountains of the northwest, mountain sheep are included, while in the northern Barren Grounds, the caribou is hunted. In the olden days the big gray wolves of the plains used to follow the buffalo herds, but with the disappearance of the buffalo the wolf turned to the increasing domestic stock for a food supply. For this reason the wolf became exceedingly unpopular and was destroyed on every occasion.

Gunflint Lake on the northern border of Minnesota was selected as the location for this group. Across the lake is the shore of Ontario. This lake was a portion of the Old Canoe Route to the West. The eastern timber wolf (*Canis lupus lycaon*), the form of gray wolf pictured here, is the same subspecies that formerly ranged throughout eastern North America as far south as Georgia.

Eastern Timber Wolves

The Coyote

Canis latrans Say

The coyote, prairie wolf or bush wolf, as this animal is known in different sections of its habitat, is one of the few large animals in North America which is extending its range. Originally a creature of the open country of the West, it has moved north in Alaska and has gradually worked its way east as far as Ohio. Coyotes have been reported in most of the eastern states but the majority of these animals have been introduced through human agency. They frequently cross with the domestic dog and many of the animals taken in the East have been this hybrid. There is a variance of opinion as to the desirability of the coyote. To the sheep ranchers the coyote is unpopular, for it kills lambs, chickens and turkeys, but the cattlemen and agriculturists value it as one of the chief factors in keeping jackrabbits, ground squirrels, prairie dogs, and other grass and grain feeding rodents in check.

The coyote is very prolific. Three to ten young may constitute a litter, but the number is generally from five to seven. The den is usually a hole dug by the animals themselves, or the burrow of some other animal, such as a badger, may be enlarged to suit their own needs. At other times a safe retreat among the rocks may be used. Both parents assist in supplying food for the pups. If caught young, the pups become very tame and make attractive pets. It is because of this that many of the animals have been transported and introduced into places outside their original range.

Unlike the wolf, the coyote seems to thrive near civilization. It is well able to take care of itself. It soon learns how to avoid traps and can be so secretive that few are aware of its presence. Constantly being hunted, trapped and poisoned, the coyote appears to be holding its own over much of its former range although it is becoming rare in some sections. The yapping howl of the coyote is one of the characteristic sounds of the true West. It is aptly stated that the West would not be the West without the coyote's serenade.

A pleasant June day in the Yosemite National Park forms the setting for this scene. Bridal Falls can be seen in the distance. The animals are the mountain coyote (*Canis latrans lestes*).

The Jaguar

Felis onca True

The jaguar is the largest and most powerful of the American cats. Its spotted coat reminds one of the Old World leopard, but it has a more massive head, heavier body and shorter tail. As a general rule the spotting of the jaguar along the back and sides is made up of much larger rosettes than the spotting of the leopard. These rosettes contain distinct spots in the center. Occasionally leopards will show this type of spotting, but the larger rosettes are diagnostic.

The jaguar occasionally crosses into the United States from Mexico. At one time jaguars were not uncommon in southern California, Arizona, New Mexico and Texas. Now, however, this large cat is rare anywhere north of the Mexican boundary. From this northern limit of its range the jaguar is found in suitable country south throughout Central and South America to central Argentina. About sixteen forms of the jaguar are now recognized, differing in size, coat color, and skull characters. This animal reaches its largest size in the Matto Grosso district of western Brazil. The jaguar inhabiting the United States is one of the smaller forms. A large specimen may weigh up to 300 pounds.

Although the jaguar is generally an animal of the deep tropical forests, it is also equally at home in arid, thorn-bush country. It climbs well and is perfectly at home in the branches of a tree. An expert swimmer, it has often been observed crossing wide rivers. River banks are one of its chosen haunts.

The jaguar often turns stock killer and is large enough to kill cattle and horses, but through much of its range it depends upon the droves of peccaries to furnish it food. Deer, capybara, and tapirs are also taken as well as lesser game. Although a more powerful animal and fully as capable, it seldom turns man-killer as the leopard is known to do. Like the leopard, the jaguar in some sections of South America has developed a great fondness for dog flesh.

Two to four cubs generally constitute a litter. The young are spotted but the fur is longer and more woolly than the adults.

The scene of the group, Box Canyon near Caraymas, western Sonora, Mexico, shows a pair of jaguars looking over the valley in which there is a stock corral.

The Mountain Lion

Felis concolor Linnaeus

The mountain lion is truly an American cat, with no near relatives in the Old World. In the New World it has the most extensive range of any of the large American mammals.

Puma, panther, cougar, painter, catamount are among the names given to the mountain lion in different parts of his domain in the United States, and in the Spanish-speaking countries many more exist. It is interesting to note that throughout this vast territory only one species of mountain lion has developed, while thirty subspecies are now recognized, eleven of which are found within the borders of the United States.

Found from Canada to the southern tip of the mainland of South America near the Strait of Magellan, it has disappeared from the more densely settled portions of its former range. In the eastern states a very limited number still inhabit the Big Cypress Swamp in southwestern Florida, and recently good evidence shows that it still occurs in New Brunswick. Almost yearly there are reports of animals having been seen in Vermont and New Hampshire, but as no specimens have been taken in these states in recent years, proof in the form of a collected specimen is desirable.

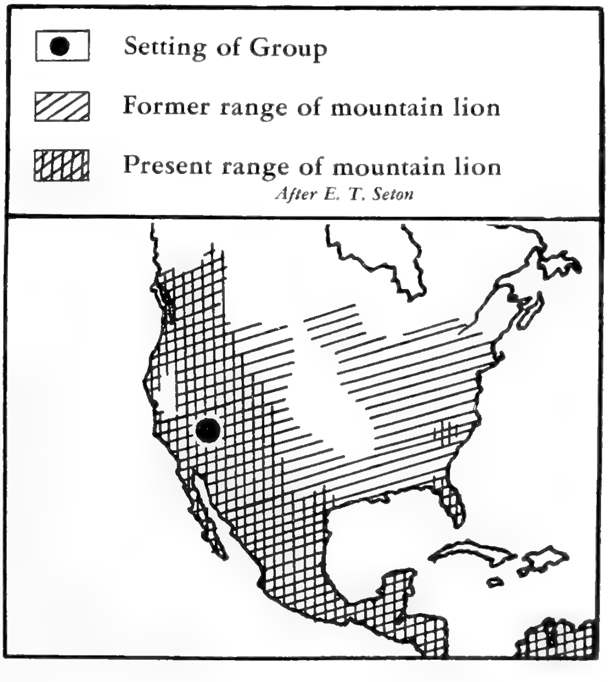
Like all the cats, the mountain lion is strictly a flesh-eater. Over much of its range, deer form its favorite food, and it carries on a most useful service in keeping the deer herds in check. In certain sections of our country where predators have been eliminated, deer have increased so rapidly that the country is unable to provide sufficient food and consequently the deer have starved. Besides deer, the mountain lion feeds on mountain sheep, mountain goats, wapiti, rabbits and domestic stock. It seems to have a partiality to colts. A hungry lion will sometimes kill and eat a porcupine with no ill effects.

The mountain lion is a very secretive animal and is seldom seen. The usual way of hunting it is to follow it with dogs until it is treed or brought to bay. This is generally accomplished only after a hard chase over rough terrain. It appears to have an extreme sense of curiosity, and will prowl around a camp throughout the night or often follow a person through the forest for miles, keeping at a safe distance. There are very few authentic records of mountain lions having attacked humans.

The home den of the mountain lion may be a cave or fissure in the rocks, or is frequently a clump of dense undergrowth. The young usually number two, three and sometimes four, and are spotted for the first six months of their lives. The female alone takes care of the kittens.

Much has been written about the voice of the mountain lion. That it does give forth cries similar to those of a domestic cat magnified many times is a certainty, but many of the so-called cries and screams that have been heard and credited to this animal were undoubtedly made by another means. There are many old time hunters who have hunted lions all their lives who claim that they have never heard one of these animals scream or make any other outlandish noise. A contented mountain lion purrs exactly like a domestic cat. If taken young, mountain lions often remain tame and affectionate towards their master.

The setting for this scene is the north rim of the Grand Canyon, Arizona, looking south from Point Sublime. The canyon's walls contain the world's most complete historical-geologic record.



The Cacomistle

Bassariscus astutus (Lichtenstein)

The cacomistle is known by many other names, including ring-tailed cat and civet cat. It is found in the southwestern United States, its range extending north as far as Oregon along the coast, and including the countries as far south as Panama. It inhabits cliffs and rocks but is also found in the dense thickets of cacti and chaparral. Usually the cacomistle makes its home in a cave among the rocks, but it can climb readily and sometimes uses a hole in a tree. Much of its food consists of mice and woodrats, but other small mammals, birds, insects, fruit and other vegetable matter are eaten.

The cacomistle is related to the raccoon and coatis. If captured young the cacomistle will become tame and make an interesting pet. However, it is unfortunate that its nocturnal habits make it less active during the day.

The cacomistles here represented are the Texas cacomistle, (*Bassariscus astutus flavus*).

The picture illustrates a peculiar habit of this skunk which is evidently a warning to an approaching enemy.

Ship Rock, in the northwestern corner of New Mexico, is seen in the background of this group.

The Spotted Skunk

Spilogale tenuis Howell

The spotted skunk, often miscalled "civet" by the fur trade, is a much more active and weasel-like animal than the larger striped skunk. It is capable of climbing trees, which the striped skunk cannot do.

Feeding on insects, birds, their eggs, reptiles and small mammals, it is an expert mouser and on some farms is encouraged to make its home around the buildings. In certain parts of this country spotted skunks are called the hydrophobia skunk from the belief that their bite is sure to produce rabies. It is unquestionable that occasionally the spotted skunk will be bitten by an animal that has rabies, since it is an animal that can easily be caught by a dog, coyote, or some such animal already infected, but this skunk is no more likely to be of danger than the common skunk, dog, fox or coyote. Thousands of men have spent thousands of nights sleeping on the ground where this skunk is common, with no ill effects.

The spotted skunk has an extensive range. It is found in central Florida, and from the mountainous sections of Georgia, the Carolinas and Virginia west to the Pacific coast. It reaches its most northern limit on the coast just crossing the border into British Columbia. In the south the range extends to Central America. Many different forms have been described. The species here represented is (*Spilogale tenuis*), the Rocky Mountain spotted skunk.

The Striped Skunk

Mephitis niger (Peale and Beauvois)

The striped skunk is one of our best known small mammals. It is conspicuous and unafraid, depending on its characteristic scent for protection.

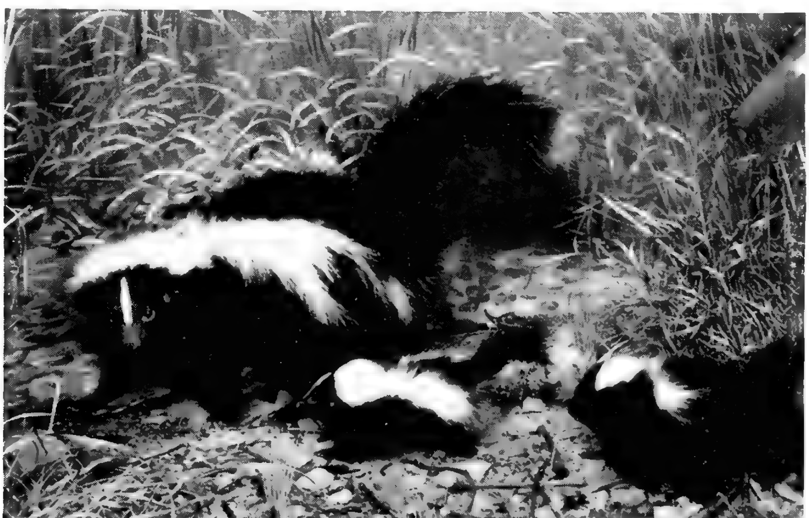
The skunk is very beneficial to the agriculturists. Not only does it destroy mice, but it is also very diligent in hunting noxious beetles and digging out their larvae, and is well known as a persistent enemy of the Japanese beetle. In late summer much of its food consists

The Spotted Skunk and Cacomistle

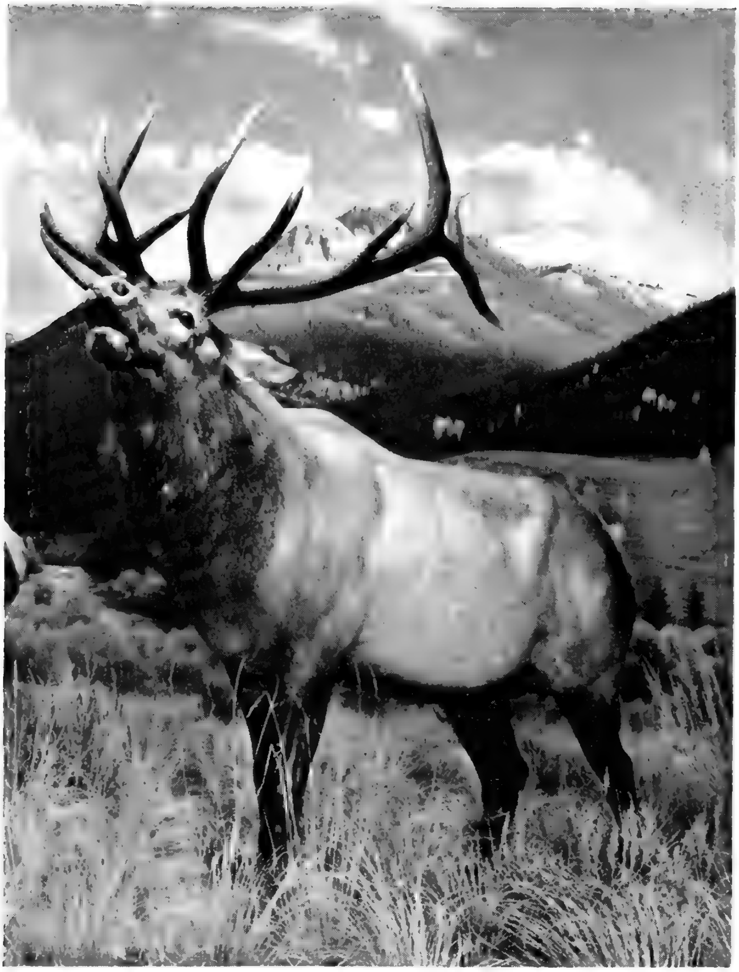
of grasshoppers and crickets. The nests of the yellowjacket are often dug out from the ground, the skunk appearing indifferent to the protests of the insects. It occasionally visits the hen house, and has a black name because of its fondness for bird eggs, but it is an established fact that the good the skunk does well outweighs the harm.

A skunk's family may consist of as many as ten young, but five to seven appear to be the average number. The home is often an old woodchuck's den, or it may be a burrow dug by the skunks themselves. During the coldest part of the winter the skunk will sleep soundly in its den, often in company with a number of others. However, if the weather is not too severe, it will sally forth in search of food.

This skunk family is viewed from the New Jersey side of the Delaware Water Gap. It is twilight on an evening in early July, and the mother skunk is just starting out on a foraging expedition with her brood.



The Striped Skunk



The Wapiti

Cervus canadensis
(Erxleben)

The wapiti, perhaps better known in North America as the elk, is second only to the moose in size among the New World deer. It formerly ranged over much of the United States and southern Canada from the coastal plains of the Atlantic to the Pacific. At the present time it is restricted to the eastern Rocky Mountain region, the Olympic Forest in Washington, Vancouver Island and sections of the south-western provinces of Canada. Wapiti have been re-introduced into some of their old haunts in the East and are establishing themselves where given sufficient protection.

A small subspecies, known as the dwarf or tule elk, inhabited the San Joaquin Valley in California. The majority of these were killed but strict protection saved a few survivors.

The wapiti is the most stately of our deer. The immense antlers, which are recorded up to $64\frac{3}{4}$ inches, are renewed annually. These are generally shed in March and by September the new ones have completed their growth and have been cleared of velvet.

In the Rocky Mountain region the wapiti spends the summers in the higher altitudes. As the snows increase they are driven down to the more sheltered valleys. Stock and fencing have made it difficult for the wapiti, and their winter range has become greatly restricted so that they are forced to congregate in large herds. In places the herds are so extensive that the food supply fails. Jackson Hole, Wyoming, is such an example and there artificial feeding is carried on by the National Government.

A single spotted calf is born in May or June.

The site of this group is along the White River, Trapper's Lake region in northern Colorado.

The Mule Deer

Odocoileus hemionus
(Rafinesque)

The mule deer is a deer of the West. Although similar in height to the whitetail, it is of a more stocky build. It differs from that animal also in its rounded, black-tipped tail and much larger ears. The antlers differ from those of the whitetail in the fact that the second and longest tine generally branches, forming a fork. The deer has a high bounding gait which is not as graceful as the easy run of the whitetail, but is more useful in broken country such as the mule deer frequently inhabits.

The mule deer is found from central Alberta and Manitoba into northern Mexico and in the Rocky Mountains from southern Alaska to Lower California. At one time it extended as far east as the Dakotas, Minnesota, and Nebraska but it has become extinct in the eastern part of this range.

In the mountainous parts the deer ranges well up in the mountains but retreats into the more sheltered lowlands before the heavy snows. It is both a grazer (feeding on grass) and a browser (feeding on leaves and twigs), but seems to prefer the latter when obtainable.

Twin fawns are the rule. These are most often born in June and are spotted like those of the whitetail.

The Devil's Tower and the Belle Fourche River are depicted in the background of this scene.

The Whitetail Deer

Odocoileus virginianus (Boddaert)

The whitetail or Virginia deer is the best known big game animal of North America. It ranges from the Atlantic Seaboard on the east to central Washington and Oregon on the west, and north through southern Canada. To the south, close relatives are found well down in South America. It is lacking in the desert regions of the west and has been exterminated in much of the plains area. Although consistently hunted, if given protection it is well able to take care of itself and in many places it is extending its range. It prefers second growth to forests, and the rank undergrowth of abandoned farms affords it abundant food and thick cover. Chiefly a browser, it eats many woody plants. In many places in the east, it is on the increase.

The whitetail deer differs from the other deer in its antler formation. The main beam extends out and forward and in a well-developed head has three or more upright tines. The number of these tines does not necessarily represent the animal's age. The first year generally produces a single spike. Under normal conditions the antlers become larger with more points until the animal reaches its full prime. After the animal is nine or ten years old his antlers are inclined to deteriorate and grow smaller as he gets older. The food and condition of the animal are important factors in the antlers development. Another character of this deer is its long bushy tail, the edges and underpart of which are white, a very conspicuous feature as the animal habitually raises the tail when running.

The spotted fawns are born in late May or June. Twins are the rule although a young doe generally has a single fawn. Occasionally there are triplets.

This picture representing a fall scene, shows a buck, doe and fawn of the year at Island Pond, Bear Mountain Park, New York.

Osborn's Caribou

Rangifer arcticus osborni Allen

The Osborn's caribou is one of the largest and darkest of the Barren Ground caribou. It is found in the mountains of northern British Columbia and in southern Yukon. This caribou is local in its distribution and does not migrate in the manner of the Stone's caribou, which is the common caribou in Alaska. The antlers of the Osborn's caribou are inclined to have a greater palmation than those of the Stone's caribou, but individuals differ greatly in this respect. In habits this animal resembles the mountain caribou of Alberta and southern British Columbia, and at one time was placed in this group.

At the present time the caribou of North America are placed in three groups according to their habitat: the Barren Ground caribou, the mountain caribou, and the woodland caribou. The mountain caribou at one time ranged as far south as the mountains of Washington, Montana, and Idaho. The woodland caribou is a large, dark caribou with shorter and more compact antlers, which are generally much palmated or even flattened on the beam. As its name implies, this is a forest animal, its range extending from Newfoundland through the forested sections of Canada to the Rocky Mountains.

The reindeer of northern Europe and Asia is the Old World representative of the caribou.

The setting for this group is the Summit of Level Mountain, fifty miles northwest of Telegraph Creek, in the Cassiar Mountains of British Columbia.

Grant's Caribou

Rangifer arcticus granti Allen

The Grant's caribou is an isolated form of the Barren Ground caribou, restricted to the Alaskan Peninsula and Unimak Island. It is slightly smaller in size and lighter in color than the race on the mainland of Alaska, which is Stone's caribou. On account of its restricted range Grant's caribou does not make the seasonal migrations for which Stone's caribou and other species of Barren Ground caribou are noted.

The main food of the caribou is lichens and grasses, but they will also feed on mosses and willows, as well as on other plants.

Caribou differ from the rest of the deer in the fact that the female carries antlers, although they are much smaller than those of the male. The coat of the caribou is comprised of hollow, air-filled hairs which protect the animal from freezing weather and conserve the warmth of the body. The hoofs are large and spreading, which make them suitable for travelling over the soft muskeg or winter's snow.

The caribou has always been an important source of sustenance for the people of the Arctic regions both as food and as clothing. In northern Alaska where caribou have become rare, domesticated reindeer have been imported.

The site of the Museum group is Sand Lake on the Alaskan Peninsula.

The Alaskan Moose

Alces gigas Miller

The moose is the largest deer in the world, and is found in the forests of northern North America, Europe and Asia. In Alaska it reaches its maximum size and greatest horn development. In the Old World it is known as the elk. The horns of the elk are usually much inferior to those of the North American moose.

In North America the moose is found in the forests of northern United States and Canada from the Atlantic to the Pacific. In the mountains it ranges as far south as Wyoming. Three forms of the moose occur in North America: the common moose found from eastern Canada and Maine to the Rocky Mountains; the Shiras' moose which occurs in Wyoming, southern Idaho and Montana; and the Alaskan moose of Alaska.

The moose prefers country of thick timber and numerous lakes. It is a browser, feeding on leaves, twigs and bark, and shows a preference for willows, alders, maples and birches. In the summer it spends much of its time wading in the lakes, not only for ridding itself of insect pests but also to feed on the succulent water plants.

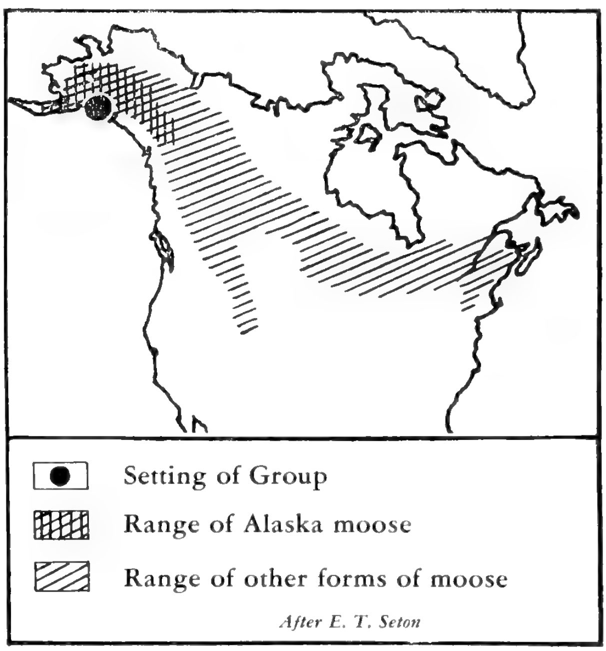
The mating season usually begins in the middle of September. During this time the bulls are on the move and many battles, such as the one depicted, occur. Twin calves are the rule, but a young cow generally has a single one for her first. Occasionally there are triplets. The young are reddish brown and unspotted.

In late winter the bulls shed their horns and almost immediately a new pair begins to grow. By September they have reached their full size and the velvet has been shed.

Many of the northern Indians are quite dependent on the moose for food and clothing. Besides man the chief enemy of the moose is the wolf. This is especially the case in the winter when the wolves have the advantage of the deep snow. Bears occasionally take a calf but seldom molest the grown animal.

The moose on the right is carrying a very exceptional pair of antlers with a 77$\frac{5}{8}$ inch spread, which at the present time consitutes the world's record.

The Kenai Peninsula, Alaska, forms the background for this scene of action.



After E. T. Seton

The Pronghorn

Antilocapra americana (Ord)

The pronghorn or pronghorn antelope has the distinction of being classed in a family by itself. It is given this distinction mainly on account of its unique horns. Its horns are true horns which grow over a bony core, the type which are known as hollow horns, and yet it is the only mammal with this development of horns which has a single branch on the horns and sheds them annually. Deer shed their antlers each year, but antlers or solid horns, are made up of bone and break off where the antler is attached to the skull. In the Bovidae or hollow-horned mammals, which include the cattle, sheep, goats, true antelopes, and musk oxen, the horns grow over a permanent bony core which is attached to the skull. These horns are made of a hardening of the epidermis, the same material which forms hoofs and finger nails. After death such a horn may be easily removed from its bony core. Except in the pronghorn it is retained throughout life. The growth of the pronghorn's horns is unique. Before the outer sheath is dropped the new horn has already begun growth. This growth begins at the tip of the core and progresses downwards to its base. After the new horn has become fully developed, the protecting sheath drops off. Both the male and the female may carry horns, but those of the female are smaller or may be lacking entirely. The greatest length of horn which has been recorded is 20¼ inches.

The pronghorn formerly ranged from southern Alberta and Saskatchewan south into northern Mexico. Creatures of the open plains and the treeless rolling country of the foothills, these animals have keen eyesight and are credited with being the swiftest afoot of any Northern American mammal. Depending chiefly upon these accomplishments for their safety, they prefer country where they can see long distances and there is no obstruction for their speed. They are both browsers and grazers, feeding on sagebrush, greasewood, grasses and cacti.

In former days the pronghorn rivaled the bison in numbers. Like that animal it was slaughtered in untold thousands and its range was turned over to sheep and cattle until it reached its low ebb in about 1908. Unfortunately the pronghorn does not take so kindly to captivity as does the bison and will not do so well in small enclosures. Wise restrictions were placed upon the killing of this animal and reserves were set aside where it received absolute protection. Due to these precautions the pronghorn is making a satisfactory come-back and the fear of its extinction has been removed. Constant vigilance and strict protective measures are still necessary if the pronghorn is to remain a member of the North American fauna.

The male pronghorn stands about three feet at the shoulders and weighs about one hundred pounds. There is a large white patch of hairs on the buttocks. These hairs are longer than the body hairs and the antelope has the power to raise them at will. When the animal is disturbed or startled these hairs are raised and flash out a conspicuous warning to the animal's companions.

The young antelope are born in May or June. Two are the general number but triplets occur on rare occasions. The young are very skillful in hiding and their grayish brown unspotted coats harmonize remarkably with the surroundings. When the kids are about three weeks old the mother and young join other mothers and form small bands which remain together throughout the summer.

The American Bison

Bison bison (Linnaeus)

The American bison, often called the American buffalo, formerly ranged over all the plains regions of North America, from the Appalachian Mountains to the Rocky Mountains, and from the region north of Great Slave Lake to northern Mexico. Throughout the Great Plains area they roamed in countless thousands and it was estimated that their number exceeded 60,000,000. By the beginning of the nineteenth century they were decreasing rapidly and by 1900 there were less than 1000 living American bison in existence and it was feared that the animal would become extinct. The American Bison Society was formed to conserve the existing animals and through the efforts of this society and other interested persons, the bison have made a remarkable come-back. They breed readily in captivity and on reserves. At the present time there are few truly wild bison but there are numbers on reservations in a semi-wild state.

In the most northern part of the bison's range, just south of Great Slave Lake, a large dark form of the bison occurs. On account of its habitat it is known as the wood bison, (*Bison bison athabasca*). Instead of living in the open plains this animal frequents the forests of balsam, jack pine, spruce and muskeg country, which is ordinarily more acceptable to the moose or woodland caribou. Here is the last stand of the truly wild American bison. However, even this animal is doomed, for plains bison have been introduced into the southern part of his realm and are interbreeding freely, so that in the very near future it is very probable that there will be no true wild bison untainted by the blood of semi-wild stock.

Before the advent of the white man the Indians of the plains were dependent upon the bison for food, clothing and tepees. It was the custom of these Indians to follow the migrations of the bison so that they could be near their food supply.

A fully matured bull bison in his winter coat is truly a majestic animal. He may stand as high a six feet to the top of his shoulder hump and weigh as much as 1800 pounds. The record length of horn is 22¾ inches. The cows are smaller and rarely reach the weight of 800 pounds. The young calves are of a brownish red color and when but a few days old are able to join and mingle with the herd. The mother is devoted to her young and often defends it successfully against the attack of the big gray plains wolves, which, next to man, are the bison's most persistent enemy.

The bison is a grazing animal, its chief food being the buffalo grass which once covered the plains.

The scene of the group is early autumn between Rawlins and Saratoga, Wyoming, in the days when the great herds of bison roamed this country. It was near this spot that the Overland Trail crossed the North Platte River.

The Musk Ox

Ovibos moschatus (Zimmerman)

The musk ox is restricted to the Arctic tundras of North America. More closely related to the goats and sheep than to the true cattle, its nearest relative is the takin, an animal found in the mountains in and adjacent to northern India and western China. Three forms of the musk ox are now recognized. One form, the barren ground musk ox, is the most southern, reaching the shores of northwestern Hudson Bay and north to Carnation Gulf. Unfortunately this animal is fast disappearing from much of its old habitat. A smaller, darker, more northern form is known as the Hudson Bay musk ox (*Ovibos moschatus niphoecus*) and the white fronted musk ox (*Ovibos moschatus wardi*) is found from the east coast of Greenland westwards to Grant Land and Banks Land. This is the most northern and most common of the three forms and is characterized by the white on the face and forehead.

The musk ox is covered with a long coarse outer hair with a thick layer of soft wool beneath, thus enabling it to endure the subzero temperature of its northern home.

The food of the musk ox consists of lichens, mosses, grasses and willows. Musk oxen do not migrate as do the caribou. During the summer they congregate in small herds, generally one bull with a number of cows. The extra bulls go around alone or else join in small groups with other bulls. However, in the winter they gather into larger herds and their differences are forgotten. The single calf is born in April or May.

This cold Museum scene shows a group of these animals at the Bellows, Discovery Harbor, northern Ellesmere Land.

White Sheep

Ovis dalli (Nelson)

The white sheep or Dall's sheep, as it is sometimes known, is of a smaller size and carries more slender horns than the bighorn. The range of the white sheep is throughout the mountainous parts of Alaska and northern Yukon. In the northeastern Yukon, animals occur with gray hairs on their bodies and legs and a dark tail, while farther south the coat darkens until finally in southern Yukon and British Columbia the blackish brown Stone's sheep (*Ovis dalli stonei*) occurs.

The habits of the white sheep are very similar to those of the bighorn.

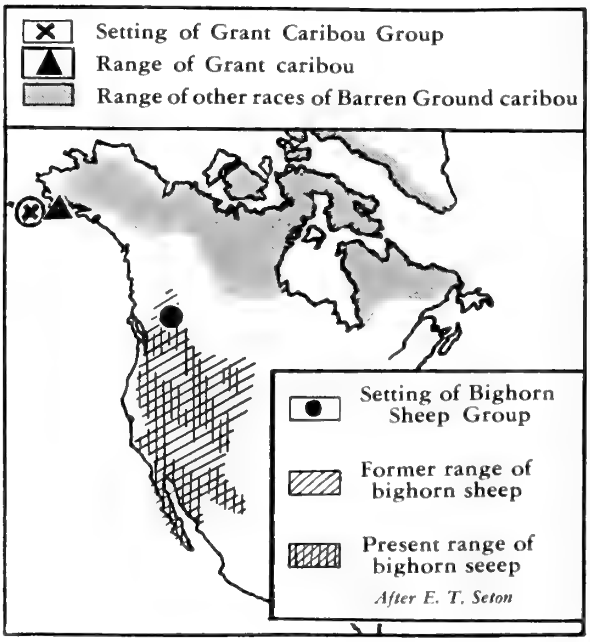
Mount McKinley National Park with the summit of Mount McKinley rising in the back ground forms the setting for this group.

The Rocky Mountain Bighorn

Ovis canadensis Shaw

The Rocky Mountain bighorn and its numerous subspecies formerly ranged throughout the Rocky Mountains from southern Alberta and British Columbia south to northern Mexico and the southern part of the peninsula of Lower California. It extended as far east as the Dakotas and Nebraska. In the eastern part of its range it has now been exterminated, and it has become reduced in numbers throughout all of its original habitat.

The bighorn is beyond doubt the most coveted prize of the big game of North America. Where it has been much hunted this animal is keenly alert, and it possesses remarkable vision, making it a difficult animal to hunt. Its home is among the rugged picturesque ridges, making the hunting not only one of the most arduous but also one of the most scenic.



The bighorn is both a grazer and a browser. Summers are spent well above timber line, the ewes, their lambs and young rams keeping in flocks separate from the old rams, which join the ewes in November. Occasionally the rams may remain in company with the ewes and lambs throughout much of the winter but by spring they seek the company of other rams high up among the lofty peaks. In winter the sheep may descend to more sheltered locations near timber line.

The lambs are born in late May or June and after a few days are able to follow the mother Twins are the rule, but a single lamb is occasionally born to a young ewe and triplets are not unknown.

The horns of the ram on the right are the present world's record, with a measurement of 49½ inches along the length of the front curve on the right horn.

The site of this group is Jasper Park, Alberta, looking south from the upper slopes of Mount Wilson.

The Bighorn Sheep

Rocky Mountain Goat

Oreamnos americanus (Blainville)

The Rocky Mountain goat is not a true goat but belongs to the group of animals known as the Rupicaprinae or goat-antelopes. Other members of this group are the chamois of Europe and the serow and goral of Asia. The coat of the goat is pure white, occasionally with a yellowish stain. It is long and thick and in the winter there is a thick layer of underfur or wool. The goat is well protected from the severe climate of his native haunts. Its home is the high ridges of the Rocky Mountains from southwestern Alaska south into Washington, Montana, and Idaho.

The mountain goat's outstanding accomplishment is his ability to climb. In this he can even surpass the mountain sheep, and he depends on this ability to protect him from his natural enemies, such as the wolf, bear and mountain lion. However, the golden eagle may occasionally take a newlyborn kid that is left unprotected by its mother.

Unlike most of the animals which inhabit the high mountains, the goat does not move down into the sheltered valleys at the approach of winter but seeks shelter on the lee side of the rocks and finds his food on the wind blown area. The mountain goat feeds on lichens, mosses, bushes and grasses.

The single kid, sometimes two, is born in April or May and follows its mother when but a few days old.

The Rocky Mountain goat group is located at Ford's Tenor Inlet, Endicott Arm at the foot of Sawyer Glacier, southern Alaska.

The Jack Rabbits

Black-tailed Jack Rabbit
Lepus californicus Gray

Antelope Jack Rabbit
Lepus alleni Mearns

The jack rabbits of our western plains take their name from their long donkey-like ears. The best known is the black-tailed jack rabbit, with a range over much of the western United States, from Missouri to the Pacific Coast and from the state of Washington south into central Mexico. The name "Jack Rabbit" is a misnomer, for the jack rabbit is not a rabbit but a true hare. As with all hares, the young when first born have their eyes open, are fully haired, and are able to move about. Three or four generally constitute the size of a litter and they are born on the surface of the ground. It is only on very rare occasions that a jack rabbit will seek refuge in a hole in the ground. It is dependent on its speed for safety, as well as on its ability for hiding.

The black-tailed jack rabbit is found in numerous types of country but shows a decided preference for sage brush. The coyote is perhaps its chief enemy, although the eagle, large hawks, and owls, and the larger carnivorous mammals prey upon it when the opportunity presents itself. The coyote is the one animal that is most successful in hunting it down. On account of the destruction of the coyote and other predators in certain parts of the West, jack rabbits have increased to such an extent as to be destructive to agriculture. Large drives are formed in which the jack rabbits are driven into fenced yards and killed. At times thousands are killed in this way in a single drive.

The antelope jack rabbit is the largest of the jack rabbits. It is further distinguished by its larger ears which lack the black tip. It is essentially a creature of Mexico but crosses the border into southern Arizona and New Mexico. Its habits are much the same as those of the black-tailed jack rabbits. However, it prefers mesquite and cactus for cover rather than sage brush. The antelope jack rabbit has one habit that is its alone. When running away the white colored fur of the underparts and flanks are pulled suddenly up on the sides of the body, giving the hare the appearance of a white animal. This is sometimes done in a jerking motion, causing a white flash, very much after the manner of the pronghorn antelope. It is this similar habit of the two mammals that gives the antelope jack rabbit its common name.

The jack rabbits feed upon the leaves of many perennial plants, and even eat cactus during the dry months.

Rancho Tanqua Verde, near Tucson, Arizona, is the setting for this group.

The Cottontail

Sylvilagus floridanus
(Allen)

The cottontail, better known to most people as the rabbit, needs no introduction. Give it some cover of tangled briers in which to hide and it is as much at home in a city yard as on a farm or wood lot. It eats a great variety of plants, and is often destructive to agriculture. The cottontail and the gray squirrel are perhaps the most frequently observed of all our wild mammals and are the first game to tempt the young hunter.

The cottontail is very prolific. There are several litters each season and each brood may number from three to seven. It is fortunate that this is the case for the enemies are legion. Not only the hunter but hawks, owls, weasels, foxes, cats and dogs, in fact any of our carnivora, count it as their legal game and hold it in high regard on their bill of fare.

The nest is a small depression on the surface of the ground lined with grass and the mother's hair. The young are helpless, blind, and hairless at birth but mature rapidly, and at the age of three weeks are no longer dependent on their mother.

In the case of the true rabbit of Europe the helpless young are born in burrows below the ground. The young of the true hares are born fully developed, well haired, with eyes open, and are able to run about shortly after birth. Therefore, our cottontail is neither a true rabbit nor a true hare.

The common cottontail is found throughout the United States east of the Rocky Mountains, and is extending its range in southern Ontario. The Rocky Mountain region is the home of the mountain cottontail (*Sylvilagus nuttallii*), and the desert, or western cottontail (*Sylvilagus auduboni*), is found throughout the south-western United States and Mexico, with its range extending as far north as Montana.

Our local form of cottontail, the eastern cottontail (*Sylvilagus floridanus mallurus*), is found in the eastern coastal states from Florida to Massachusetts. The New England cottontail (*Sylvilagus transitionalis*) inhabits the more mountainous section from Maine to Alabama. West of the mountains Mearns's cottontail (*Sylvilagus floridanus mearnsii*) is found.

Ithaca, New York, the site of this group, is near the eastern limit of the range of this form.

Triumph of the Mammals

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By EDWIN H. COLBERT
Curator, Department of Geology and Paleontology

THE AMERICAN MUSEUM OF NATURAL HISTORY

TRIUMPH OF THE MAMMALS

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Illustrated by

Margaret M. Colbert

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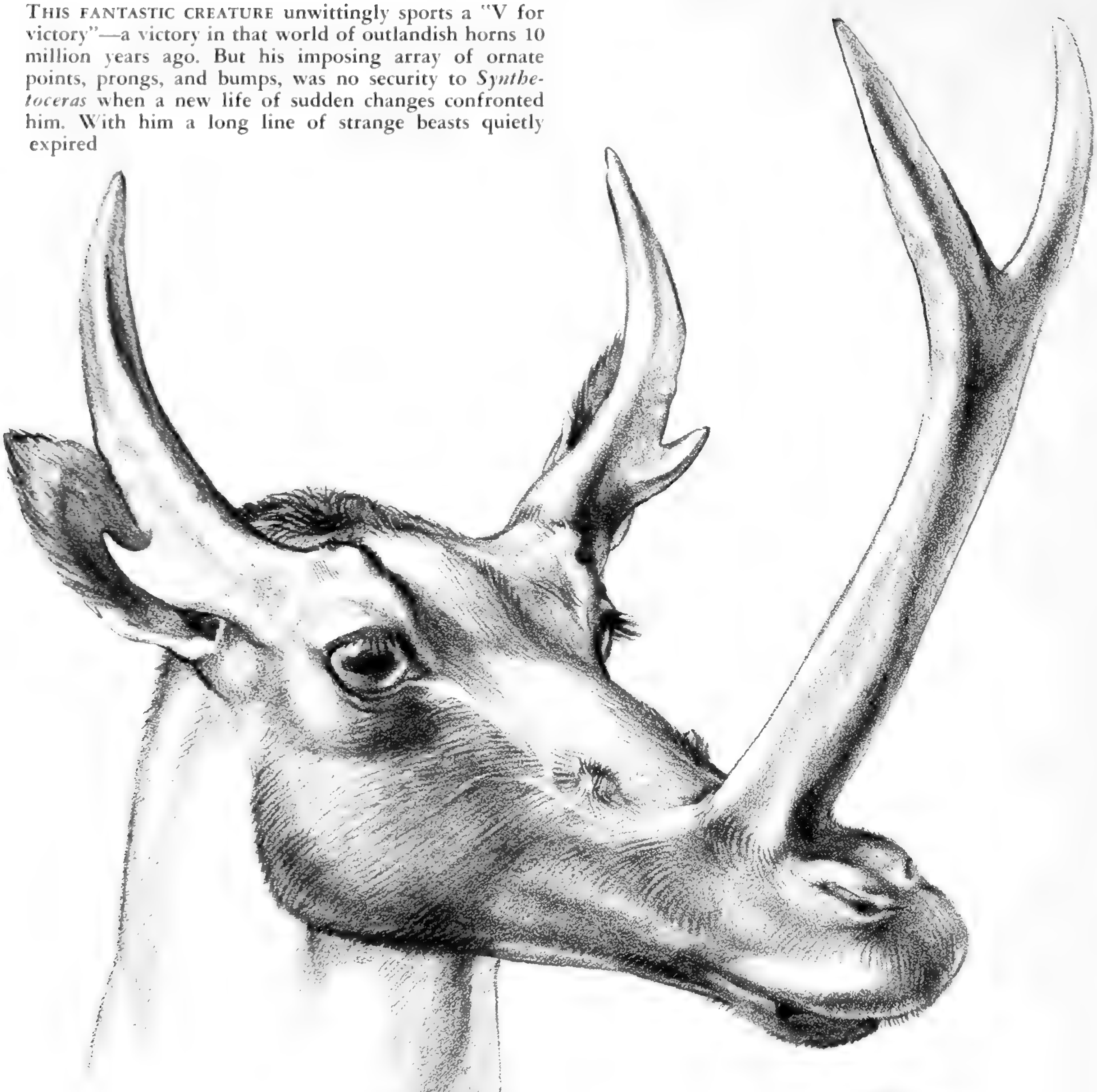
THIS FANTASTIC CREATURE unwittingly sports a "V for victory"—a victory in that world of outlandish horns 10 million years ago. But his imposing array of ornate points, prongs, and bumps, was no security to *Synthetoceras* when a new life of sudden changes confronted him. With him a long line of strange beasts quietly expired



(Right) STRANGE, LONG-FACED PECCARIES once lived in Nebraska

(Opposite) A "conservative" of the Age of Horns: *Sphenophalos* may well have been an ancestor of the persistent line of North American antelopes, of which the pronghorn is sole survivor

CIRCUS without spectators

No human eye witnessed the parade of strange creatures in that age of superspecializations, but science reconstructs the surprising pattern from which our modern animals emerged

For millions of years after the disappearance of the last dinosaurs and on through the long period during which archaic mammals were dominant on earth, the geologic history of North America, of the world for that matter, progressed in a steady and, one might say, comparatively placid fashion. Lands that were low and tropical when the mammals first began to flower were gradually uplifted to become high, grassy plains. Imperceptibly the mountain chains of the West came into being. The entire continent slowly pushed up and up until the landscape took on those features of hill and vale, mountain and plain closely resembling its present-day lineaments.

And with the implacable evolution of the continent toward its more modern form there were concurrent developments among the mammals, which had inherited this strange new world from their reptilian ancestors.

The mammals, it will be remembered, are the warm-blooded animals which generally give birth to living young instead of laying eggs and are able to nurse their offspring through earliest infancy. The importance of this chapter in evolution is evident when we realize that it concerns the ancestry of our most familiar four-footed animals of forest and plain. At first changes were slow, as Doctor Simpson has pointed out. There was a long period of "experimentation" during which many of the early experimental models were tried and many were found wanting, but out of the great melange of strange, primitive beasts which evolved between 40 and 60 million years ago during the earlier phases of the Tertiary period, some forms, more adequately fitted for continuation than their contemporaries, survived to give rise to the great mammalian faunas of later Tertiary times.

The later phases of the Tertiary period, notably the Miocene and Pliocene epochs, were preeminently the Age of Mammals. This was the time for the culmination of many lines of mammalian descent; it was the time when the earth was inhabited by hordes of beasts of different kinds and of high specializations. These numerous four-footed mammals, many of them of peculiar form and aspect, truly reigned supreme, for at that time there was not yet the unquiet and disturbing biped known as Man to contest their rule of the earth. They lived their separate but integrated lives unseen by the avid human eye. They marched and countermarched in imposing array across the face of the continent in processions of magnitude. They were the menagerie of an ancient circus without spectators.

These animals of the late Tertiary were for the most part wonderfully adapted to the environments in which they lived. They were suited to almost every conceivable "ecologic niche" of the late Tertiary world—that is, they were specialized to varied modes of life on the plain and in the forest, to grass-eating and to meat-eating, to burrowing and to climbing, to protection by virtue of their great size, and to escape by running. All of the exigencies of life on the land were met by the evolutionary development in these animals. Like the animals of

our present-day world, these late Tertiary mammals had become modified to take advantage, each in his own fashion, of the varying conditions around them.

They were like the mammals of our present-day world, yet unlike them. True enough, many of them were the ancestors of our modern types of animals and as such were intermediate between their earlier ancestors and their present-day descendants. They were distinctly and greatly advanced over the animals of early Tertiary times from which they had sprung, yet they were still sufficiently lower than their modern grandchildren to appear noticeably primitive to the modern eye. On the other hand, many of the animals of late Tertiary times were end products in themselves and had developed along lines that seem to us strange and bizarre; they were the rococo designs in mammalian architecture.

What was the world like in those distant days? Let us project ourselves back through the mind's eye to a scene in the western part of North America of that ancient day—say some seven or eight million years ago, at about the beginning of the Pliocene epoch.

In those days the high plains of the West were not greatly different in appearance and development from what they are today. There were extensive rolling grasslands cut into mosaics by shallow streams, along which grew fringes of trees and small bushes. The climate was warm and fairly arid, perhaps without the extremes of temperatures that are so characteristic of that region today. Very likely the winters were considerably less frigid than our modern winters, so that there was in North America an environmental condition not unlike that of the modern African veldt.

Most apparent in the scene of that day, even as now, would have been herds of hoofed mammals that lived on the open prairie, and of all the later Tertiary mammals perhaps none were more markedly different from their modern counterparts than these grass-eaters.

Rhinoceroses in Nebraska may seem to be something of an anachorism to us, but there they were. Not the rhinoceroses of today, but heavy squat short-legged animals, ungraceful and almost hornless. It may be that these were water-loving rhinos, spending much of their time along the shallow watercourses of those ancient plains.

Drifting across the grasslands were herds of horses, — unmistakable horses, but horses in miniature. For these later Tertiary horses, though various, were all of pony size. Some of them were of the three-toed type, the persistent and conservative followers of their ancestors of ages long past; others were the more progressive single-toed horses, foreshadowing in form and structure their descendants of modern times.

Peccaries lived in ancient Nebraska, not the peccaries that we know from our modern tropical and subtropical America, but large, long-faced peccaries, many of them with large projections or bumps on their cheeks, so that they must have looked something like the wart hogs of present-day Africa.

If the rhinoceroses of later Tertiary times may be styled as "sawed-off," the North American camels of that age were just the opposite, the slim-jims of their day. These were greatly elongated animals, with stilt-like legs and giraffe-like necks, towering into the rarified upper strata of the available food supply. And though strange of form, these perpendicular camels should not be regarded as strange in their occurrence, for the entire heritage of these animals was peculiarly North American. Here they arose and developed, and it was only at a later date, in the great Ice Age, that the camels emigrated from their North American homeland to newer lands, finally to become extinct in the land of their origin.

Here also were the last of the oreodonts, a group of hoofed mammals that lived and developed through a major portion of the Tertiary period. They were unlike anything now living, rather short-legged animals, some of them as large as sheep. The head was remotely sheep-like, rather deep and without any horns or bony outgrowths; and they had four well-developed toes on each foot, and a long tail.

But strangest of all the varied grass-eaters of those distant plains were the numerous horned and antlered forms. Here were deer-like animals with horns or antlers of a bewildering variety. Many had the usual pair of such structures at the back of the head above the eyes, in some cases curved in, in other cases curved out, in some cases directed backward, in other cases pointing forward; but others had prongs and points jutting out of all sorts of strange and unexpected places on their skulls, which gave them nightmarish aspects, to say the least. Our knowledge of these peculiar horned animals has been greatly augmented in recent years by the collections of the Frick expeditions of the American Museum—indeed, a whole new world of peculiar mammalian types has been opened up as a result of this work.*

This was an age of *three-horned* animals, of beasts which sported a single median horn in addition to the usual pair above the eyes. One of these triple-horned grazers, *Synthetoceras* by name, had two very adequate and ornate structures over the eye sockets and then, as if this weren't enough, he had an unbelievably long prong, forked at its tip, projecting up from the front of the nose. In addition he had a couple of small knobs on the sides of the skull. And then to supplement this array of points, prongs,

* *See* Childs Frick, "Horned Ruminants of North America," *Bulletin of the American Museum of Natural History,* LXIX (1937).

and bumps, a pair of well-developed canine teeth or tusks peeped out from beneath his fleshy upper lip. Needless to say he was one of those end products of evolution, and with him a long line of strange beasts quietly expired. Which is our loss, for he must have been something to look at. Bounding along with his head up before the prairie wind on a stormy day, he must have looked like some sort of peculiar three-masted schooner with all of the canvas hauled down.

Another one of these unorthodox grazers had a third horn growing right out of the back of his skull, like the stern flagpole of a small ship. Our knowledge of this animal, known as *Cranioceras,* came about as follows: about forty years ago, the late Dr. W. D. Matthew, then Curator of Fossil Vertebrates at the American Museum of Natural History, found in northwestern Nebraska the single median horn of this animal and recognized it for what it was. He named the animal on the basis of this fragment, and predicted what might be expected when the entire skull should be found. Many years later, not one but several skulls of *Cranioceras* were found by the Frick parties, and they showed a median horn, as Matthew had phophesied, but they also showed what Doctor Matthew had no way of guessing, namely the additional pair of horns above the eyes. Even so, this confirmation of Doctor Matthew's shrewd prediction indicates the depth of knowledge and perception possessed by that great paleontologist.

Of course not all of the horned animals were quite so outlandish as these three-horned fellows. Indeed, some of the horned grazers of that distant day were relatively conservative, and as might be expected these were for the most part the ancestors of persistent evolutionary lines. For instance, there was a large variety of antilocaprids, of which our modern prong-horned antelope is the sole survivor. Some of these early antilocaprids were rather deer-like, with branched "antlers" on their skulls, but others, although tending to favor the ornate in their horn development, were even then prophetic of the prong-horn. There were other horned grazers, too numerous to mention, but perhaps this gives some idea of what might be expected of these animals in North America during the Pliocene age, several million years ago.

It was an age of horns—even the rodents had them. In the late Tertiary deposits of the high plains there was a whole series of horned gophers characterized by transversely paired horns on the nose.

Grazing and browsing with the hoofed mammals on the open plains were the tusked and trunked mastodonts, the Tertiary forerunners (but not the ancestors) of our modern elephants. There were several kinds of these, most of them characterized by four tusks, two in the upper jaws—as in the modern elephants—and in addition two in the lower jaw, which was greatly elongated. All of these long-jawed mastodonts were peculiar, but perhaps the prize of the lot was the animal known as *Amebelodon,* the so-called "shovel-tusker," in which the lower tusks were not rounded in the orthodox fashion, but flattened to form broad scoops, enabling these animals to poke around in the mud and among shallow-water plants of the prairie streams for their food. In addition to the peculiarity of its tusks, the lower jaw of *Amebelodon* was unbelievably long, and one wonders how this animal negotiated hillocky ground without constantly ramming his lower tusks into the earth like a broken down wagon-tongue. At any rate, *Amebelodon* did exist, there are his bones to tell us so, and he was seemingly successful for a while. It is probable that the trunk of this animal was not round as it usual among the proboscideans or elephant-like animals, but flattened, a sort of elongated upper-lip,—which is really what it was.

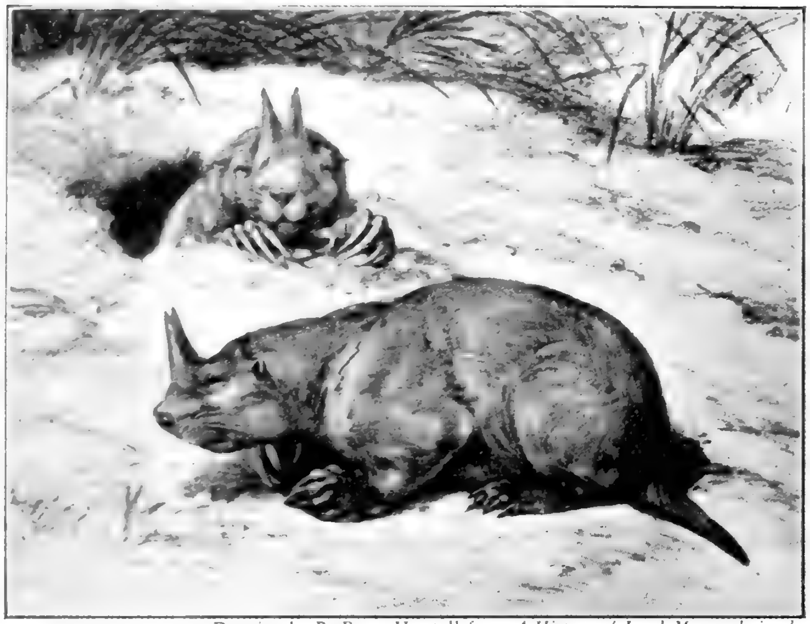
No picture of animal life is complete without the beasts of prey which live upon the grass-eaters. And there were many such hunters in Nebraska of long ago. But they did not show the bizarre developments so apparent among the grazers. Here we come into the realm of ancient dogs, some of them ancestral to our modern wolves and foxes, others of gigantic size—obviously the culminations of lines long in the process of evolution. Here were the late Tertiary cats, of different sizes but not so very different in form from our modern felids, except for those of the sabertooth variety, with their great, scimitar-like canine teeth. Here were the weasels and their ilk, the badgers and the skunks, the raccoons and all of the various lesser carnivores that found their living off the small rodents and other small fry which scampered along miniature runways through the grass roots, or sought protection beneath the soil in subterranean burrows.

Such was the Parade of Life long ago—a parade of forms both familiar and strange to the eye of modern man. In it were the ancient dogs and cats, the various gnawing rodents, the horses and other animals, marching toward a future of continued evolutionary development. But also there were in it the peculiar short-limbed rhinoceroses, the stilt-legged camels, the shovel-tusked mastodonts and the host of bizarre horned ruminants marching toward the oblivion of extinction.

Why should this be? Why should those delightfully strange beasts die out at a time when they seemingly were riding along so successfully on the crest of a wave of evolutionary development? Why did they disappear, to be succeeded in modern times by forms which to us seem by comparison so prosaic?

Perhaps it was the trend of evolution. The climate was becoming increasingly severe, the land was losing some of its long-established geniality. The lush life of the warm plains and the woodlands was over; a new life of fluctuating temperatures, of ice and of snow was in the offing. Conditions were changing, and changing at such a rate that these highly specialized animals with their shovel jaws, their short legs and long legs, and their varieties of horns and prongs could not make the adjustments necessary to survive the gathering changes, so they gradually died out, to make way for what we are pleased to call the "modernized" types that succeeded them. It is the old, old story that is told time and again in the record of the rocks. Only the fit survive, and when the environment begins to change, the fit are those which can change with it or adapt themselves to the new conditions that are being established. The highly specialized animals, no matter how well organized they may be for existence under the old conditions, must pass into the limbo of the dead if they cannot meet the stringencies of new conditions.

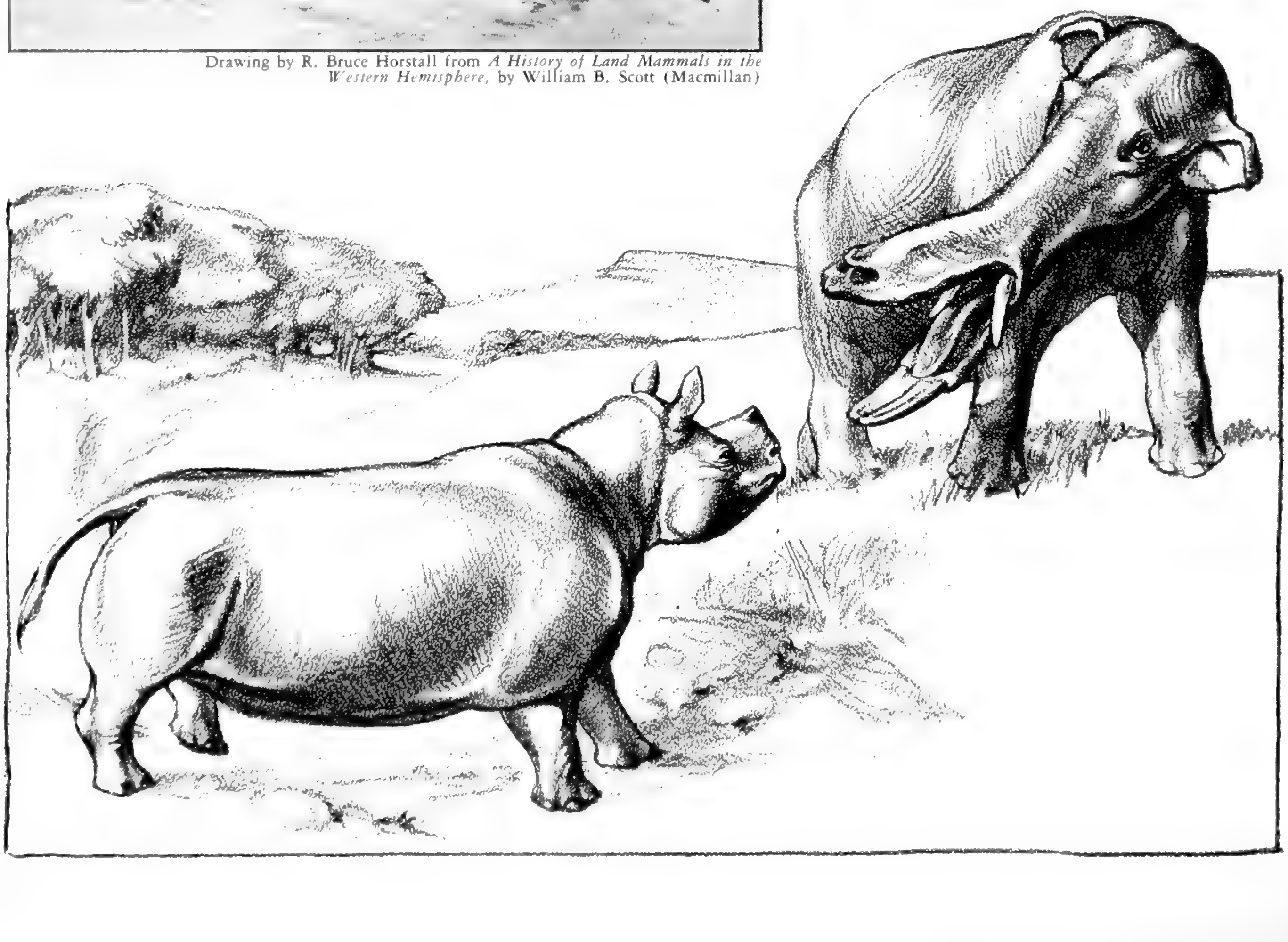
So it was that numerous denizens of America succumbed in the final stages of the Tertiary period. They disappeared before a new horde of beasts—a horde that came in with cold winds from the north, with the ice and the snow.



Drawing by R. Bruce Horstall from *A History of Land Mammals in the Western Hemisphere,* by William B. Scott (Macmillan)

Even the rodents had horns. Transversely paired horns on the nose were characteristic of the late Tertiary gophers that scampered over the western high plains of North America

(Below) **Nature's long period of "experimentation" included a squat, "sawed-off" rhino and a mastodont whose peculiar flattened tusks distinguished him as the "shovel-tusker"**

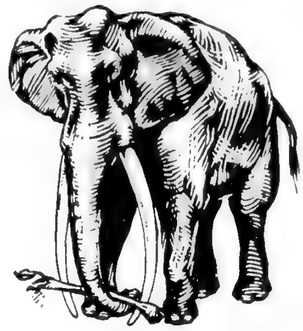


Ice-Age Mammoths

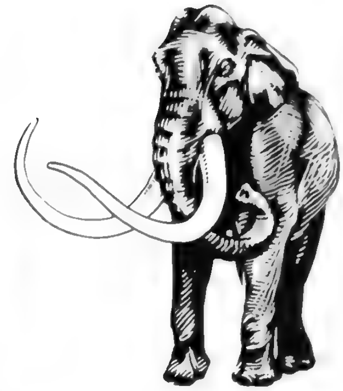
and their descendants—

All drawings
by MARGARET M. COLBERT

(*Right*) WOOLLY MAMMOTH (*Elephas primigenius*); north circumpolar mammoth; Eurasia and North America.

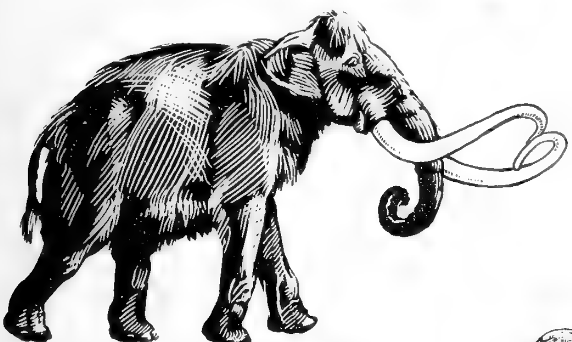


STRAIGHT-TUSKED MAMMOTH (*Elephas antiquus*); a mammoth of the Old World

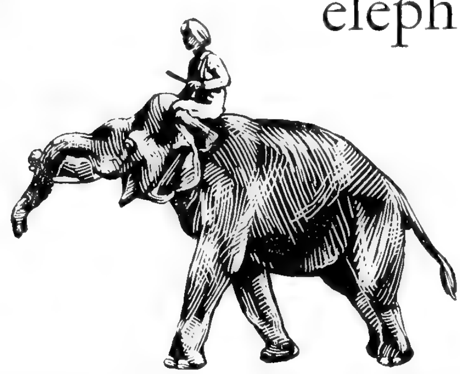


IMPERIAL MAMMOTH (*Elephas imperator*); southern North America

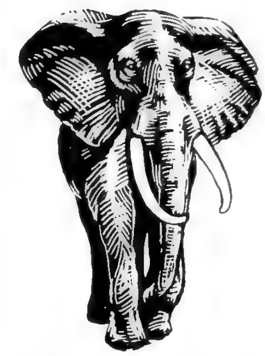
the modern elephants



COLUMBIAN MAMMOTH (*Elephas columbi*); the large mammoth of middle North America

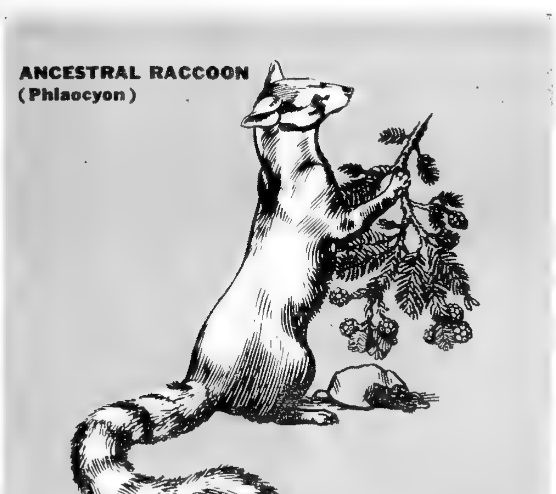


(*Right*) INDIAN ELEPHANT (*Elephas maximus*); the survivor of southeastern Asiatic mammoths



AFRICAN ELEPHANT (*Loxodonta africana*); survivor of mammoths of Eurasia and Africa

TERTIARY CARNIVORES



The beasts of prey were less bizarre than the hoofed animals that grazed across the plains of ancient North America. The grandfather of the raccoons (Phlaocyon) resembles the living cacomistle or ringtailed cat (Bassariscus) of Mexico and our Southwest.

In late Tertiary America lived *Hemicyon*, a "bear-dog." As large as a black bear, this animal possessed an admixture of dog-like and bear-like characters which make it an almost perfect intermediate form between the early dog-like carnivores and the modern bears.

LONG BEFORE WHITE MAN set foot upon our shores, horses and tapirs had left North America, presumably for "greener pastures." But while the fourth great glacier was refrigerating most of the continent, both these plant eaters were content to bask in Florida's mild climate.

ICE AGE WINTER

ARCH PREDATOR of the Ice Age was the powerful sabertooth. Small fry ice refugees — the otters, skunks, weasels, etc. — lived in terror of this giant cat. The capybara *(right)* found a haven along the Floridian streams. Though extinct in North America, this colossus among rodents persists in South America.

RESORT

Driven south in a spectacular population movement by relentless glaciers that descended upon North America, the animals discovered Florida's warm haven a million years ago

About a million years ago there began a series of new events of profound importance in the history of the earth. From the north, tremendous glaciers—icecaps of continental proportions—began to creep slowly southward to engulf the greater portion of North America, while at the same time in Eurasia there was a similar southward advance of the ice sheets. These glaciers of the northern hemisphere pushed unceasingly down to the middle latitudes, and then, just as mysteriously as they had begun their advance they halted, and finally retreated to the polar regions from whence they came.

Four times this great encroachment of the land by continental glaciers occurred, and North America, Europe, and northern Asia became regions of polar frigidity. Four times the glaciers retreated and the northern continents became warm again. It is in the last of these glacial retreats, which began some 30,000 years ago, that we are now living. We are the inhabitants of a warm interglacial age, and there is no reason to think that our descendants, in the dim future, may not witness another southward push of the ice, inevitable and relentless. All of which is in explanation of the latest events in the long history of the earth, the great Ice Age which is known as the Pleistocene.

Obviously the first glacial advance, bringing with it cold, arctic conditions, was bound to have some effect upon the animals living in the

northern continents, in North America, Europe, and Asia. The long period of gradually changing environmental conditions described in the first chapter of this pamphlet was at an end; here was the beginning of a new epoch, a period of relatively rapid changes in environment. To the new conditions the life of the earth had to adjust itself.

As has already been shown, many types of strange animals became extinct near the end of Pliocene times, even before the glacial advance had truly begun. The increasing rigors of the climate preceding the actual formation and southward push of the vast continental glaciers must have had much to do with the disappearance of the strange, highly specialized mammals of late Tertiary times. Consequently by the beginning of the Ice Age in the northern world many "modernized" types of mammals had made their debut upon the stage of paleontologic history, animals which were fitted by their adaptability to withstand the rapid and severe changes attending the first great glaciation.

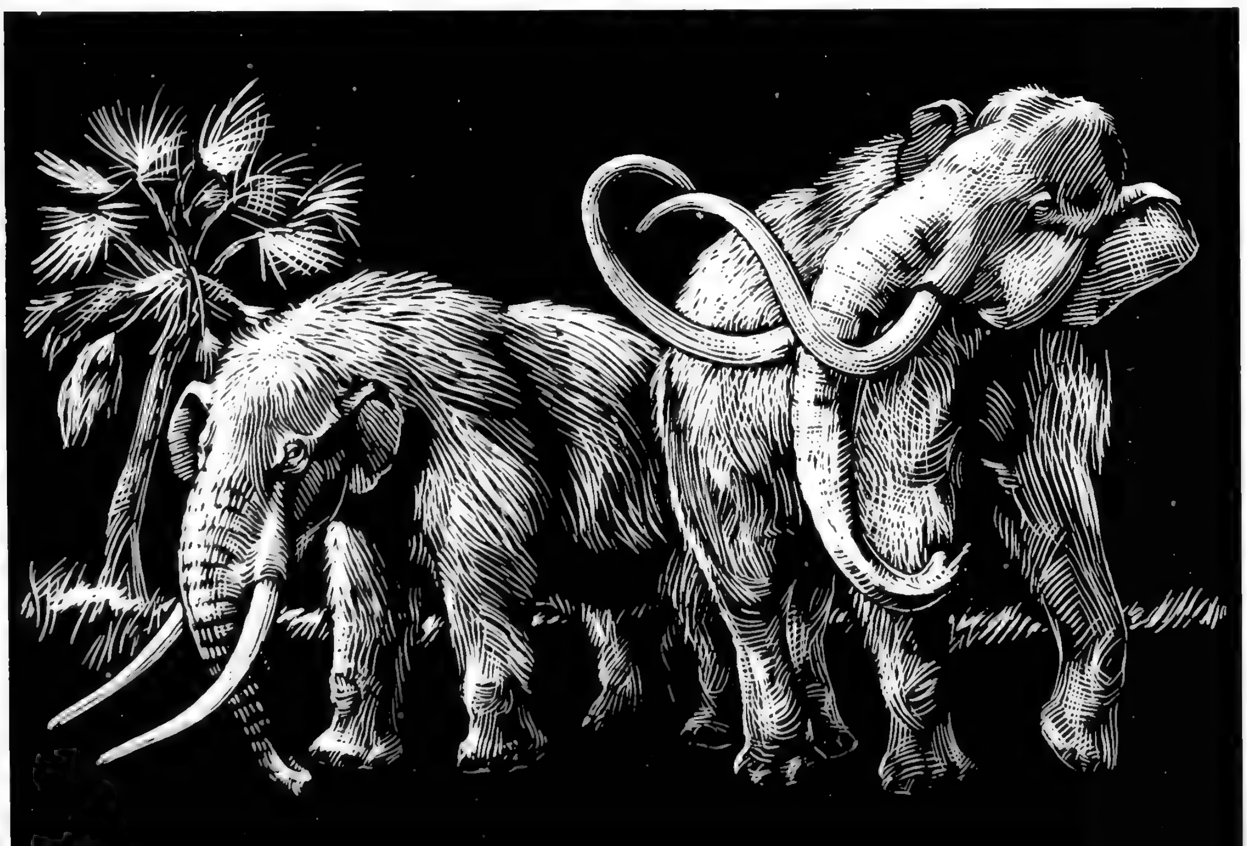
The horse and his relatives the asses and zebras appeared with the advent of the Ice Age. So did the camels and the large deer of our modern world. So did the various cattle, and with them a host of antelopes and gazelles. So did the elephants. Indeed, the sudden appearance of these new, modernized types of animals affords one of the convenient ways for recognizing the opening of the Ice Age throughout the world. The words "throughout the world" give a true impression, for a striking feature of this period was the great intercontinental and in some cases world-wide movements of certain types of these new, modern mammals. Let us look for a moment at these "migrations," if so they may be called.

The horses had evolved in North America during the long reaches of the Age of Mammals. Suddenly with the beginning of the Ice Age they broke from the confines of their homeland to spread through virtually the entire world. To the south, they pushed across the newly-established isthmus to occupy all of South America. To the west, they poured across a land connection which at that time bound Alaska to Siberia, and spread throughout Eurasia, the Orient and Africa.

With them went the camels and their relatives. The llamas, alpacas and their ilk went to South America, the large camels to Asia, the Orient, and Africa, again utilizing the Isthmian and Bering crossings which connected the continents.

But all of the movements did not originate in North America, for there were corresponding flows in the other directions. The elephants, whose Pleistocene representatives are known as mammoths, originated in the Old World and crossed the Bering Bridge into the New World to occupy all of North America. With them came the cattle, specifically the bison, an immigrant which we think of as being the veritable symbol of America.

Bears and large deer also came from the Old World into the Western Hemisphere, although forerunners of these animals already inhabited this region; while from the opposite direction gigantic ground sloths, which had been evolving in South America, crossed the Isthmus to take up a new abode in a northerly environment.



Mastodons and mammoths also pushed their bulky weights to the Ice Age Winter Resort. Though conditions seemed ideal for their continuation, both disappeared from earth—leaving science with still another tantalizing "why?"

These are only a few of the great movements of animals that took place with the coming of the Ice Age, but perhaps they indicate the extent to which the early Pleistocene was a period of animal migrations. Newly evolved animals pushed from one land to another, from north to south and south to north, from east to west and west to east. It seems as though a shuffling of animal populations was necessary to strike a new balance in the changed world.

These were the great movements that heralded the opening of the Ice Age. But what happened after these initial phases of the Pleistocene period had run their course?

We have already seen how there were four glaciations, how the ice advanced four times from the north polar region and how after each advance it retreated to the far north again. With these advances and retreats of the glaciers there were corresponding movements of the mammalian populations. As the ice came down from the north the mammals withdrew southward ahead of the glacial front. Then, during the interglacial stages, as the ice retreated to polar regions, the mammals spread northward again to occupy those regions from which they had been driven by the polar cold. Thus the Pleistocene animal populations may be thought of as pulsating communities, ebbing and expanding as the glaciers advanced and retreated, constantly shifting back and forth as the environment changed. Theirs was a life of rigorous changes, not within the experience of the individual it is true, but within the existence of the species. Such was the story of mammalian life in North America during the fluctuating course of the great Ice Age.

As the glaciers pushed down from the north and crowded the animals before them, the influx of life into the southern portion of North America caused added pressure and competition during the glacial stages. Somewhere, somehow, a balance must be attained, or the pressure of animal populations would reach an explosive state. This balance was found, very likely, in the "safety valve" of Mexico and the Central American region. As the animals pushed in from the north, the southern animals retreated as best they could into the lower end of the North American horn. Thus by constant movements and adjustments the various animal populations could become more or less established in progressively smaller areas.

But on the eastern side of the continent such adjustments could not be made. Florida offered a warm haven for animals driven south by the polar cold, but it was a "dead end." Moreover it was a relatively small area, so that its accommodations for immigrating animals were necessarily limited. Consequently there seems to have been little penetration from the north, and life went on in Florida during the Pleistocene undisturbed by the flowing and ebbing glaciers. Here was an old-fashioned environment, with the rather monotonous conditions of existence that had prevailed over much of North America in earlier geologic ages. Here the tenor of life continued much as it had in the past.

To the eye of imagination, what would the Florida scene of that age look like? Very much as it does today, with certain additions. As in present-day Florida, there would be a host of small animals inhabiting the underbrush and hammocks, scurrying through the grass out of

"Nails in the gloves." The hook-like claws of the giant ground sloth enabled him to ward off the attacking sabertooth. The turtle-like shell of the strange glyptodont (*right*) offered passive but effective resistance

sight of the predator's eye. Here would be opossums and shrews, rabbits and various kinds of wild mice, muskrats, and squirrels. But splashing around in the streams in decided contrast to his tiny rodent brethren would be the large capybara, the giant among the rodents, now living far to the south in South America.

There would be numerous hunters such as are found in Florida today, the gray fox, skunks and weasels, raccoons, otters, and lynx. But dominating these pilfering seekers of small prey would be great, powerful predators such as one would hardly care to meet at close quarters. Fierce wolves would be seen loping across the hard open ground, while gigantic bears, long since extinct, would be found in the thickets. Great cats would be seen gliding through the forests like wraiths: the jaguar, found now in lands to the south, and the powerful saber-toothed cat, arch-predator of the Pleistocene, which disappeared from the earth thousands of years ago.

It is among the more peaceful types of animals, the grass-eating and browsing forms, that the Pleistocene fauna of Florida would seem strange to our modern eye. First one would en-

THE GREAT MIGRATIONS O

THE striking feature of the Ice Age was the great intercontinental, and in some cases, world-wide reshuffling of animal populations. North America gained as well as lost. The bison — veritable symbol of America — came from Asia. From North American plains the camel trekked his way to a new home in Asia and Africa. The Bering and Isthmian bridges made possible these mass movements

counter the bizarre giant ground sloths and the glyptodonts, immigrants from the south and cousins to the armadillo, an immigrant that still lives in this region. These were stupid and inoffensive animals, depending largely on their size for protection. The giant sloth probably could ward off the aggressive saber-toothed cat by using his hook-like claws, while the glyptodont, covered with a turtle-like shell, could pull in his head and offer passive but effective resistance to the enemy.

Then there would be the horses and tapirs, both living elsewhere today, but both destined to become extinct in North America long before white man set foot upon these shores. The horses fed in the open glades, while the tapirs, like their modern relatives, probably stayed along the streams, splashing through the water and browsing on the succulent leaves hanging over the banks. In the wooded stretches there were large peccaries, pig-like animals whose much smaller cousins survive today in southern North America and the regions to the south. In the open spaces camels would be seen, grazing alongside herds of deer and black masses of large bison. And in the streams, sea cows and

alligators would raise their heads as they swam along, even as they do today in Florida.

Finally there would be the gigantic elephant-like animals, the mastodons and the mammoths, crashing through the forests and stripping leaves from the trees with their powerful trunks. These were the dominant but tolerant lords of the entire scene, afraid of nothing but the elements.

Such was Florida in the Pleistocene. And such was North America during the warm interglacial stages of the Ice Age. The difference was that this picture continued in Florida with but little change throughout Pleistocene times, whereas over much of North America the landscape was altered by the advance of the glaciers. At such times many of the animals that enjoyed a relatively tranquil existence in the Ice Age Winter Resort of the peninsula were in other regions driven to the south by encroaching reindeer, muskoxen, giant beavers, and woolly mammoths.

Such was the Florida that was found by the distant forerunners of Ponce de León—the first men to come to America from Asia. That was many thousands of years ago—how many we do not know. What we do know is that early man in Florida was living with all of these animals, with the types which still exist in this region and with those giants which long since became extinct in this land—the horse and tapir, the capybara, the saber-toothed cat, the ground sloth, the camels, the mastodon and the mammoth.

Why should these animals have become extinct, particularly in a land that seemingly was so amenable and so well suited for their continuation? This is a tantalizing question to which we shall probably never know the full answer. Suffice it to say that the great, dominant mammals of the Pleistocene became extinct all over North America *after* the arrival of man on this continent. Did man have anything to do with their disappearance?

Whatever the cause, the fact is that they did become extinct, but not until after the last glacier had begun its retreat to the north. Thus the "modern" period of our earth history was ushered in. Florida, the Ice Age Winter Resort for the Pleistocene mammals became the winter resort for modern man. The rest of the continent, subjected to periodic alternating cold and warm epochs, again became temperate.

But are we at the end of the cycle? Who knows but that in some future period, some tens of thousands of years hence, our descendants, perhaps completely civilized by that time, will really find Florida more than a winter playground? Perhaps it will be for them a haven, far removed from the great, crushing front of the fifth continental glacier, riding down over our northern cities.

Reading List

Bradley, J. H. *Parade of the Living.* New York: Coward-McCann, 1930.

Colbert, Edwin H. "Nebraska—Fifteen Million Years Ago." NATURAL HISTORY Magazine XXXV, 1935, pp. 37—46.

Colbert, Edwin H. "Mammoths and Men," NATURAL HISTORY Magazine, XLVI, 1940, pp. 96—103.

Fenton, Carrol Lane. *The World of Fossils.* New York: D. Appleton-Century Co. Inc., 1933.

Fenton, Carrol Lane. *Life Long Ago.* New York: Reynal, Hitchcock, 1937.

Knight, Charles R. *Before the Dawn of History.* New York: McGraw-Hill, 1935.

Lucas, Frederick A. *Animals of the Past.* 7th edition. New York: American Museum of Natural History, 1929.

Lull, Richard Swann. *Organic Evolution.* 2nd edition. New York: Macmillan & Co., 1929.

Matthew, W. D. *Climate and Evolution.* 2nd edition. New York: New York Academy of Sciences, 1939.

Matthew, W. D. and S. H. Chubb. *The Evolution of the Horse.* 7th edition. New York: American Museum of Natural History, 1927. 1939.

Raymond, P. E. *Prehistoric Life.* Cambridge: Harvard University Press, 1939.

Romer, Alfred S. *Man and the Vertebrates.* 2nd edition. Chicago: University of Chicago, 1941.

Scott, W. B. *A History of Land Mammals in the Western Hemisphere.* 2nd edition. New York: Macmillan & Co., 1937.

INSECTS, TICKS AND HUMAN DISEASES

by

C. H. CURRAN *and* FRANK E. LUTZ

The American Museum of Natural History
New York, New York
1942

Issued under the direction of the
Committee on Popular Publications.
ROY W. MINER, *Chairman*

FRONTISPIECE. — A MODEL OF A FEMALE YELLOW FEVER MOSQUITO, *Aedes aegypti*.

INSECTS, TICKS AND HUMAN DISEASES

A Brief Statement of Facts
Vitally Important to Man

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The American Museum of Natural History
GUIDE LEAFLET No. 113
New York, 1942

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INSECTS, TICKS, AND HUMAN DISEASES

by

C. H. Curran and Frank E. Lutz

One of the varied and exceedingly important relations between man and insects is the transmission of serious human diseases by a relatively few kinds of insects. In some cases the transfer is purely mechanical; in other cases the insect is an essential part of the development of the disease. During war, when men gather in large numbers or enter regions containing diseases to which they are not immune, the seriousness of the spread of diseases by insects is greatly increased.

The Diptera are by far the most important disease-carriers among the winged insects. Unlike most other insects, Diptera never have more than one pair of wings. They are the flies, mosquitoes, and midges. Fleas and lice, all wingless, are the other insects that are outstanding in this connection. Ticks, which are not insects, are also very important carriers of disease.

DIPTERA

The mosquitoes may be known by the long, piercing, sucking mouth (proboscis), and the presence of scale-like hairs on the wings. They are moderately fragile and have long slender legs.

The midges are generally more delicate than mosquitoes. They lack the scales on the wings and even those that bite (some very small ones) have rather short mouthparts. Some of the larger midges are often mistaken for mosquitoes; but, since they do not "hum" and are not attracted to people, they are soon recognized as harmless.

"Flies" is a general term applied to the more robust members of the Diptera, regardless of size. The term is perhaps best exemplified by the house fly, green- and blue-bottle flies, and other flies in houses, and by the deer and horse flies that attack people in the woods. There are many thousands of different kinds of flies but only a relatively small number of them bite.

MOSQUITOES

The mosquitoes are divided into three main groups but only two, the Anopheline and Culicine, are important. There are disease carriers in both groups. The Anopheline group is well known because some of its members transmit malaria. The mosquitoes that carry yellow fever belong to the Culicine group. Other diseases are transmitted by members of each group.

Anopheles mosquitoes are readily distinguished from other adult mosquitoes because they have the scutellum almost evenly convex apically; the abdomen is usually without scales or they are few in number. When an *Anopheles* is at rest the body is held at an angle of about 45°. The wings of most species are spotted. The eggs

are laid singly or in loose masses and have characteristic floats. The larvae are surface feeders and rest with their bodies parallel with the surface of the water.

Culex, Aedes and other Culicines have the scutellum concave toward the sides so that it is trilobed; the abdomen is wholly covered with scales. When these mosquitoes rest or bite their body is parallel to the surface. The wings of only a few of the species are spotted. The eggs may be laid singly, in loose masses, or in compact "rafts" but they do not have individual floats. The larvae rest at an angle to the surface of the water.

MALARIA

It has been authoritatively stated that malaria is "a disease of world-wide incidence and the cause of a higher sickness and death-rate than any other disease" (Encyclopaedia Britannica). In addition to deaths directly due to malaria, the disease weakens its victims, destroying their efficiency and making them more susceptible to other diseases.

A malarial parasite in man was first identified in 1880 by Charles Louis Alphonse Laveran, a French military physician then serving in Algeria. He received the Nobel prize for medicine in 1907. The parasites are one-celled animals of the genus *Plasmodium*, distantly related to amoebae. Their lives in the human body are relatively simple. An individual parasite enters a red blood cell and feeds on the cell's contents. When fully grown the parasite divides into a number of parts, each part being a new individual parasite. These youngsters break out of the blood cell in which they were formed and, for the most part, each of them enters another red blood cell to repeat the "asexual cycle." However, some of them, instead of being sexless, are either male or female. These sexual individuals float about in the blood stream and eventually die unless one of certain kinds of mosquitoes sucks them into its stomach.

The part played by certain mosquitoes in the transmission and, indeed, in the propagation of malaria was made clear in the last three or four years of the nineteenth century by the work of MacCallum (an American working on malaria in birds), Manson, Ross, Grassi, Bignami, Sambon, Low and others. It is briefly as follows.

Not all of even those mosquitoes that suck human blood are involved in the malarial cycle that includes man. There are apparently some exceptions to the usual statement that it must be a species of the genus *Anopheles* but, on the other hand, not all of the species of *Anopheles* are involved.

When a mosquito sucks blood from a malarial patient the mosquito is almost certain to draw into its stomach some of the sexual forms of the malarial parasite. Then, if the mosquito is one of those kinds that are susceptible to malarial infection, male and female forms of the parasite unite and the resulting organism bores through the lining of the mosquito's stomach and remains for a while as a cyst in the muscles of the stomach. Numerous spore-like bodies (sporozoites) develop

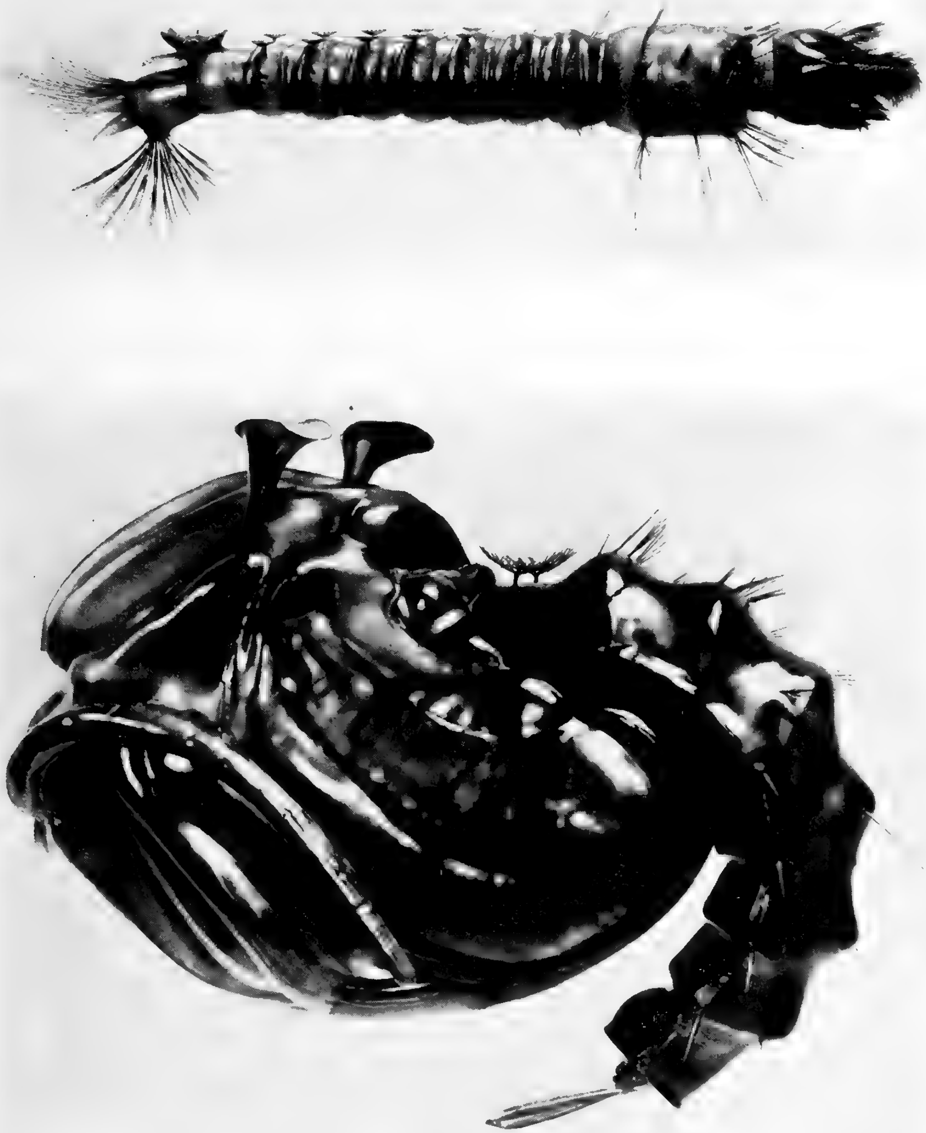

PLATE 1. — MODELS OF (ABOVE) A LARVA AND (BELOW) A PUPA OF A MALARIA MOSQUITO, *Anopheles.*

within this cyst and, after leaving it, move through the mosquito to its salivary glands. Six to fourteen days, the time depending on temperature and the kind of malaria, are required for the parasite to accomplish these changes and to move from the mosquito's stomach to its salivary glands. Until this is done the mosquito is not infective; but, after the sporozoites reach the mosquito's salivary glands, they, or at least some of them, will enter the human blood stream when the mosquito pierces a person's skin to feed. These sporozoites then change into the asexual forms living in human red blood cells; and the unfortunate human has malaria.

It will be noted that mosquitoes are more than mere carriers of malaria; they are parasitized by the malarial organism just as truly as humans are. Were it not for man, mosquitoes would not have malaria; and, were it not for mosquitoes that are subject to malarial infection, man would not have malaria. Malaria can not be naturally transmitted from one person to another except by way of certain kinds of mosquito; and bites of these kinds of mosquito will not give the bitten person malaria unless the mosquito itself has malaria.

For some unknown reason all or most of the sexual individuals in the red blood cells of a malarial patient break out of the cells at approximately the same time. It is then that the patient has the characteristic chill and fever, possibly because of poison released into the blood stream when the infected cells break. The time between attacks is characteristic of the kind of malarial parasite that is present. There are three chief kinds. *Plasmodium malariae* is the relatively rare quartan kind causing chills and fever that start every fourth day. *Plasmodium vivax* is the wide-spread and common tertian kind causing chills and fever that start every third day. *Plasmodium falciparum* is "aestivo-autumnal" or quotidian kind causing chills and fever that start every second day. The latter is also called "pernicious fever;" and the very dangerous "black-water fever" may be an extreme form of it.

A mosquito which has once had malaria may pass it on to numerous humans before it dies. James and Shute found that *Anopheles maculipennis* kept under laboratory conditions was infective for two and a half months after feeding on a malarial patient. One such mosquito could do a great deal of damage.

The mouth-parts of adult male mosquitoes are not well adapted for piercing and, so far as is known, no male mosquito ever "bites" humans. The antennae of adult male mosquitoes are decidedly feather-like; those of adult females are thread-like.

On each side of the proboscis there is a palpus, a segmented appendage that looks somewhat like an antenna. *Anopheles* females have palpi nearly or quite as long as the proboscis. In the United States most of the *Anopheles* have spotted wings. Furthermore, when resting, a female *Anopheles* usually stands with proboscis and body in a straight line at an angle to (not parallel with) the surface on which it is. If you see such a mos-

PLATE 2. — A MODEL OF A FEMALE MALARIA MOSQUITO, *Anopheles.*

quito, you may not be seeing a malaria-carrier but it is well to be suspicious of it and to act accordingly.

Contrary to common belief, a mosquito need not have a meal of blood before it can lay eggs. Many suck only plant juices, if, indeed, they feed at all. Even the blood-suckers often attack man less than they do other animals. An examination of the stomach contents of a large number of *Anopheles quadrimaculatus* in Louisiana showed that the stomach of only 4.3% of the individuals contained human blood and 95.7% of the individuals contained the blood of domestic animals. However, *A. quadrimaculatus* is one of the important carriers of human malaria. At least some species of mosquito may have races characterized by food preference, one of the races preferring human blood, another cow blood, and so on.

When mosquitoes pierce the skin to suck blood they usually inject a bit of fluid that is very irritating to some people but that may not greatly affect others. Apparently it is possible to acquire at least a partial immunity to this irritation; and possibly it is true that mosquitoes do not bite some people as freely as they bite others.

The duration of the life of adult female mosquitoes varies from a few weeks to six months or more, depending on the species and other factors. Males are relatively short-lived. Some species hibernate in the adult stage.

The immature stages of all mosquitoes are aquatic. The eggs are usually laid on the surface of water but in some cases they are laid on the damp ground of a depression where there will be a pool when rain comes. Some species, such as the common "rain-barrel mosquito," *Culex pipiens*, lays the eggs in compact masses and each mass may contain up to several hundred eggs. Most species, including those of *Anopheles*, lay their eggs singly or in loose clusters. An egg of *Anopheles* may be recognized by its having a "float" on each side.

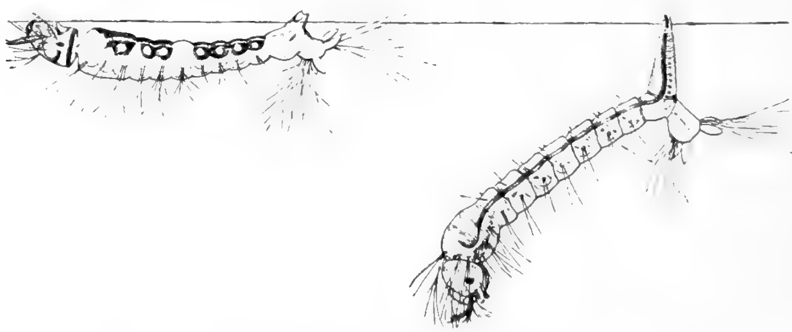

FIGURE 1. — RESTING POSITIONS OF LARVAE OF (LEFT) ANOPHELINE AND (RIGHT) CULICINE MOSQUITOES.

The larvae of mosquitoes move through the water with a lashing, twisting motion that has earned for them the name "wrigglers." Each has a "breathing tube" at the hind end of the body. When in need of air, the larva comes to the surface of the

water and pushes the tip of this tube into the air. Tracheae carry air to all parts of the larva's body. The breathing tube of *Anopheles* is relatively short and the *Anopheles* larvae when resting at the surface of the water are parallel to the surface. *Anopheles* larvae feed chiefly at the surface, eating microscopic bits of organic matter. The larvae of most other mosquitoes rest at an angle to the surface and largely feed on organic matter on the bottom of the water.

It is not unusual for larval life to be completed in a week or ten days, although some species spend the winter as larvae. Mosquito pupae are active but they do not feed. Their shape somewhat suggests a seed. The slender abdomen, folded against the thorax, serves as a paddle when the pupa moves. Instead of having a breathing tube at the end of the abdomen the pupa has a pair of trumpet-shaped tubes on top of the thorax. Pupal life is usually very short, in some cases only a day or two.

Since mosquitoes breed in water and, hence, are common in swampy districts, malaria is most common in such districts. Also, since adult *Anopheles* are most active at night, people who are frequently outdoors at night are most likely to get malaria. The old idea that malaria is caused by night air of the swamps was a natural error. Now that we know the facts, we know that infection can be prevented by avoiding the bites of malarial mosquitoes. The best method of doing this is to get rid of the mosquitoes.

Of course, the most thorough-going method of getting rid of mosquitoes is to get rid of all water in which they might breed. This is not usually entirely feasible.

Some species breed in the water in artificial containers such as cisterns, rain barrels, and empty tin cans. Cistern and rain barrels can be fitted with mosquito-proof covers. Discarded cans and the like should be buried or otherwise made incapable of holding water. Some species breed in water in the hollows of partially decayed trees; but these are rarely troublesome. If they are, drainage holes can be cut in the trees or the hollows can be filled with cement or even dirt.

Depressions containing small pools, even temporary ones, should be filled or drained. The proper drainage of swamps usually requires the cooperation of trained entomologists and engineers. Improperly constructed or clogged drainage ditches may themselves become breeding areas, particularly for *Anopheles*.

Mosquito larvae and pupae are eaten by a large number of aquatic insects, including even the larvae of some mosquitoes (*Psorophora* and *Megarhinus*). They have still other natural enemies but the most efficient natural enemies of mosquito eggs, larvae, and pupae are certain fish. Goldfish are very useful in the control of mosquitoes breeding in fountain basins and ponds kept for ornamental purposes. Top minnows, such as *Gambusia*, are recommended for anti-mosquito work, especially in the control of *Anopheles* and other mosquitoes having top-feeding larvae. Most small fish eat mosquito eggs,

larvae and pupae. In order to get the most help from fish the banks of the ditch, pond or stream should be kept clear of weeds and the edges should be sharp and free from overhangs.

If water in which mosquitoes would breed can not be eliminated and breeding can not be controlled by fish, then oil or poison must be used. Practically every kind of mosquito larva must get air by pushing the end of its breathing tube through the surface of the water and into the atmosphere. If there is a sufficient film of oil on the water, the larvae come in contact with it when they come to the surface to breath. The oil has a toxic action and it is also possible that the delicate openings into the tracheae may be clogged with the oil. Ordinary kerosene can be used for this purpose but it is expensive and evaporates rather quickly. Light fuel oils are more generally used, and sometimes pyrethrum and other insecticides are added. Oiling is of little value on running water.

Paris green, a stomach poison, has been used with success against some mosquitoes. One part of Paris green mixed with 100 parts of fine dust (ordinary dry earth) and scattered on the surface of pools or ponds at the rate of 2 ounces of the mixture to 100 square feet of surface will kill most of the *Anopheles* and other surface-feeding larvae. It is said that so little Paris green does not injure cattle that may drink the water. To kill bottom-feeding mosquito larvae the poison may be mixed with wet sand so that it will sink when scattered on the breeding areas. Not all lots of Paris green are equally effective. Samples should be tested before much is used.

Incidentally, before using either oil or other material, it would be well to ask the federal Bureau of Entomology (U. S. Department of Agriculture) or your State Entomologist for more detailed and up-to-date information than is given here.

There is no efficient method of large-scale destruction of adult mosquitoes. The advertised "traps" that electrocute insects that come to lights often do much more harm than good because they kill so many insects that are beneficial to man and so few that injure him.

The mosquitoes in a closed room may be stupefied by fumigating with burning pyrethrum powder but they must then be swept up and killed. More deadly fumigation would scarcely be attempted except in extreme cases. Thoroughly screening the house so that mosquitoes can not get into the room is a much better plan. Screen with 18 meshes to an inch is better than the more common 16-mesh kind.

The important fact that in these days of high-speed, long-distance transportation the whole world must be watched for danger from disease-carrying insects is well illustrated by the invasion of Brazil by *Anopheles gambiae* from Dakar. The essential facts are contained in the following extracts from the "Reviews" for 1938, 1939, 1940 and 1941 of the Rockefeller Foundation by its president, Raymond B. Fosdick.

1938

"If Orson Welles, in his now famous broadcast of October 30, 1938, had announced not that the Martians had landed in New Jersey, but that a mosquito called *Anopheles gambiae*, a native of Africa, had arrived on the American continent, there would have been no public alarm. Indeed it is doubtful if there would have been any public interest. But *Anopheles gambiae* is potentially a much more dangerous invader than the Martians would have been. H. G. Wells's Martians, it will be remembered, were unable to adjust themselves to life on this planet and quickly died. *Anopheles gambiae*, striking from Equatorial Africa, has invaded South America and is making itself very much at home in Brazil.

"Who is this new invader of the Western Hemisphere and how did it get here? *Anopheles* mosquitoes are malaria carriers; the *Anopheles gambiae* is the most dangerous member of a dangerous family. Although the species has hitherto been reported from Algeria and Morocco, and from Southern Arabia as well, its principal home is the African tropical belt, extending from the southern border of the Sahara Desert south to the Zambesi River. It is the scourge of Central Africa, a carrier of a serious and often fatal type of malaria, sometimes complicated by the so-called 'blackwater' fever. Until 1930 this species of mosquito was not known on this side of the Atlantic. In that year, however, or shortly before, it crossed the ocean, apparently by airplane or on one of the fast French destroyers which at that time were working in connection with the French air lines between Dakar in West Africa and Natal in Brazil. The species was first discovered in 1930 within the city limits of Natal by Dr. Raymond C. Shannon, a member of the Foundation's staff, during a routine mosquito survey in connection with the yellow fever service. The seriousness of its presence was immediately recognized, but it was hoped that the invasion might be localized by natural conditions unfriendly to the invader.

"These hopes were disappointed. In 1930 and 1931 there occurred in the vicinity of the breeding area in Natal an outbreak of malaria of a severity unprecedented in the annals of the city. The yellow fever service was compelled to undertake gambiae control in order to maintain an efficient staff for its own work. By 1931, following prevailing winds, gambiae mosquitoes had traveled up the coast 115 miles. Two years of severe dry seasons seemed to check the invasion, and then, with the recurrence of normal rainfall, the onward flight started again.

"In recent years, severe epidemics of gambiae-carried malaria have occurred in localities over two hundred miles west and north of Natal. In the Jaguaribe Valley of the State of Ceará alone there were over fifty thousand cases of malaria in 1938. Over 90 per cent of the population was affected, with mortality in certain districts estimated at 10 per cent. So disabling and widespread was the epidemic that, in some parts, crops were not planted and salt production was greatly reduced because of lack of labor. It is estimated that as a result of the ravages of this mosquito nearly every person in these affected areas will be on government relief in 1939.

"George E. Vincent, formerly President of the Foundation, in his report for 1928 wrote, 'It has been said that a good malaria fighter must "learn to think like a mosquito." He must ask: Which of many kinds of anopheline mosquitoes shall I try to imagine myself? How far is it possible to fly? When and where is food to be had? Which blood is to be preferred, human or animal? How can one get into a screened house? Where shall one rest after a good meal? Where is the best place to deposit eggs? Is the water of the right kind and temperature? Is it stagnant or flowing? Is there vegetable growth to protect eggs and larvae from fish?' Fortunately, through the work of the Foundation's staff and others in Africa, much is known about the gambiae. It breeds prolifically and rapidly, requiring only seven or eight days to develop from egg to adult, a fact that makes breeding possible in very temporary water collections. It has variable breeding habits, but seems to prefer stagnant, sunlit water. It has a high infection rate. During the outbreak in the city of Natal in 1930, 62.8 per cent of 172 specimens of gambiae caught and dissected were found to be infected with malaria, a rate higher than anything hitherto known in the Americas. The gambiae seems to prefer human to animal blood; of over a thou-

sand specimens tested in 1931, 82.3 per cent contained human blood. It is a domesticated insect; it usually bites indoors, not outdoors. Fairly reliable flight records show a distance of over three miles.

"Late in 1938 representatives of the Brazilian health service and of the Foundation staff investigated the infected area in North Brazil. They visited São Gonçalo and Baixa Verde, both of which have had heavy outbreaks of malaria following the introduction of gambiae to the region; and the lakes about Assú. They also went up the Jaguaribe River through Jaguaribe Mirim, Ouro Branco and Icó, to Lavras. This visit confirmed the seriousness of the situation. Once the gambiae gets into a river valley it spreads up the valley unless blocked at some point by natural or artificial barriers.

"With the assistance of The Rockefeller Foundation an anti-gambiae service is now being organized. Except for the distribution of quinine by field personnel working in infested districts, this service will not have the responsibility for medical care of the sick in dispensaries or otherwise. Inasmuch as there is insufficient time to develop a separate agency, it will be organized as a part of the existing local yellow fever service. This affiliation will make possible the utilization of the wide experience of the yellow fever service in the infested area and will provide a group of trained men accustomed to working under discipline. It is hoped by this method to confine the gambiae to the relatively arid areas which it now occupies, and possibly even to exterminate it there. If the gambiae should break through to the well-watered Parnahyba and Sao Francisco River Valleys, it is feared that it would be impossible to prevent its spread to a large part of South, Central and perhaps even North America. The Parnahyba Valley is 500 miles from Natal; the gambiae mosquitoes are already nearly half way there.

"In 1938 the International Health Division of the Foundation set aside $100,000 for expenditure in 1939 on the problem of the gambiae in Brazil. The Government of Brazil has also earmarked substantial sums. Funds will be released for control measures as soon as the plans of attack are drawn."

1939

"Many public health workers throughout the Americas are awaiting with anxiety the outcome of the campaign that has been organized against this mosquito. These workers realize that one of the most serious health problems facing their own countries is involved in the possibility of gambiae continuing its invasion and sooner or later reaching their territories. The tragic result of such a spread cannot be over-stated. A distinguished malariologist, Dr. M. A. Barber, has recently said: 'This invasion of gambiae threatens the Americas with a catastrophe in comparison with which ordinary pestilence, conflagration and even war are but small and temporary calamities. Gambiae literally enters into the very veins of a country and may remain to plague it for centuries. Even the penetration of yellow fever into the Orient might be a lesser evil, because its vector is domestic and more easily controlled.' . . .

"The actual field service of the campaign against the gambiae is being carried on by the personnel of the Foundation in collaboration with the Brazilian government. The Foundation has assumed the responsibility of direction and administration. Early in 1939 the Malaria Service of the Northeast (of Brazil) was created by government decree and began the task of organizing a field force to prevent further extension of the gambiae, to minimize the effects of its activity in the area already infested and to reduce its range.

"The first results in 1939 were frankly disappointing. The organization of the Malaria Service of the Northeast coincided with the beginning of the rainy season, when the gambiae advances by leaps and bounds, and this, together with the lack of personnel trained in methods of mosquito control, prevented any early apparent results of the campaign. As was anticipated, widespread epidemics of malaria occurred, and during the first few months of the Service some 114,000 persons were treated for the disease. During these early months the only visible consequence of activity was the reduction of mortality from malaria through medication of acute cases.

"By the beginning of July, however, a staff of over two thousand doctors, technicians, scouts, inspectors, guards and laborers, trained

in methods of control, was available, and even though the rainy season was unusually prolonged, appreciable results were obtained, not only in minimizing the further spread of gambiae in the frontier districts, but also in reducing the incidence of the mosquito in certain heavily infested sections to a point where careful surveys repeatedly failed to reveal the presence of either larvae or adults.

"In this campaign both climate and physical geography promise to be indispensable allies. The rainy season is restricted to 4 months out of 12, i.e., from February through May, and gambiae is a mosquito which breeds mainly in residual rain-water pools, shallow, open to the sun and without vegetation. It does not lay its eggs in permanent or deep water, in running, salty or shaded water or in water supporting aquatic vegetation. On the other hand, it takes advantage of every little depression in the ground, such as wheel tracks or hoofprints, no matter how shallow or small, which can present a water surface for eight or nine days. During the rainy season, with its almost daily showers, gambiae becomes a formidable antagonist. But for eight months in the year, the heat of the tropical sun, the strong continuous trade winds, and the low humidity combine to dry up all shallow surface waters and to make life precarious and of short duration for the gambiae. Potential breeding places are reduced to disconnected pools in the beds of the larger rivers, none of which maintains a flow in summer. Most of the higher rolling country back from the coast is practically non-infectible by gambiae. Its arid, stony soil supports a scrub vegetation composed of a resistant, thorny bush mingled with cactus. The region is without water for larvae, and without shelter for gambiae adults. The sparse population of the interior is therefore closely bound to the river systems and so also is the gambiae mosquito throughout the summer.

"The plans of the campaign against gambiae sound like the plans of an army on defense. The frontiers of the infested region are defined by fumigation posts on all the outgoing roads. These are the forts of this new kind of Maginot Line. A 10-mile zone beyond the gambiae's farthest limit of advance is to be kept non-infectible, which from the mosquito's point of view is the 'scorched earth' policy. Within this zone, as well as within the area already infected, all breeding places of the mosquito must be eliminated or treated with Paris green or other larvicide. The whole region is being mapped from the air so that no pools, ponds or other collections of water will be overlooked. The adult mosquitoes are being sought and killed in the houses with insecticide sprays to diminish the chances of their laying eggs and thus perpetuating the species in the region. Every automobile and train that leaves the infested area is being stopped, inspected and fumigated. A maritime service has been organized at points along the coast to disinfect every boat or plane bound for clean ports. It is war in a very real and grim sense, and, unlike other types of war, its purpose is the preservation of human life.

" . . . by December, 1939, gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf. If the mosquito can be held within its present limits during the wet season of 1940, we can begin to think of the possibility of its eventual eradication from the entire region. This, of course, would mean extermination of the last surviving pair. It must be admitted that eradication is a rash word in terms of prophecy. As in all campaigns, accidents may determine the issue. Thus in one case the gambiae mosquito was transported many miles into previously uninfested territory through the medium of an old automobile which used an improvised wagon road through the jungle and thus avoided the fumigation post on the main thoroughfare. In another case it was a small fishing boat that carried the mosquito up the coast, thus driving a wedge in the defense line against the spread of the disease. If the war is won, victory will come through continued vigilance. The wet season of 1940 will test the efficacy of the present measures and will be critical as far as the gambiae campaign is concerned."

1940

"A year ago we reported that the gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf of Northeastern Brazil — an area of perhaps twelve thousand square

miles. Around this area a line of fumigation posts was erected to keep the mosquito from breaking through into new territory, and a concerted advance was begun to narrow still further the boundaries of its domain. The weapons employed were Paris green for potential breeding places and spray insecticides for the fumigation of all buildings.

"This intensive campaign in 1940 had dramatic results. During the critical wet season the gambiae was pushed back on all sides, so that by the beginning of the dry season it had been practically restricted to the lower Jaguaribe Valley. This made possible the concentration in this area of a large number of workers for the final onslaught beginning in July. It can now be reported that no larvae or adults of gambiae have been found in the lower Jaguaribe Valley since the first week in September. A small additional focus lying some sixty kilometers beyond the known infested area was discovered in October, but it yielded readily to attack and was apparently clean by the middle of November. No evidence of gambiae in Brazil was found during the last forty-seven days of 1940.

"Further relevant evidence lies in the fact that in areas of earlier infestation where control measures have been progressively discontinued gambiae have not been found, even during the rainy season when the Brazilian type of anophelines flourish. In the Icó field laboratory alone, routine microscopic examination of some two million anopheline larvae, collected during the last eight months of 1940 in areas where control measures had been suspended, failed to reveal any evidence of surviving gambiae infestation. Considering the fact that the gambiae mosquito is a domestic insect with marked preference for certain types of readily observed breeding places, the failure to find either larvae or adults in an area in which no control measures are being applied seems highly significant.

"Those directing the campaign no longer consider it rash to speak of the eradication of gambiae from Brazil, although it must be remembered that the struggle will not be won until the last fertilized female gambiae on this side of the Atlantic is destroyed. In any case, no matter how many isolated foci may yet be uncovered, the critical phase of this immediate campaign seems to be over. Certain mopping-up operations remain to be done as the search is continued for infested areas. The number and extent of these areas should become rapidly apparent with the onset of the rainy season early in 1941."

1941

"A year ago we reported that it no longer seemed rash to speak of the eradication of gambiae from Brazil, although some mopping-up operations might be necessary if any areas became infested at the onset of the rainy season in 1941. It is a satisfaction to report that no such infested areas were discovered during the entire year. Except for a short period of two months in a small area in which infestation was first found in October 1940, no control measures were carried out during the year in the gambiae region, and a free opportunity was thus afforded for any remaining members of the species to increase their numbers at will. Thorough search by well-trained and selected personnel throughout the entire area of previous infestation, and even far beyond the old limits, failed to reveal the presence of a single gambiae.

"This particular battle would seem to have been won — at great labor and cost, and after enormous suffering. But the gambiae mosquitoes have apparently not given up their intention of establishing themselves in the Western Hemisphere. Airplanes are crossing the Southern Atlantic with increasing frequency, and commercial planes, of course, are now carefully fumigated, both after they leave Africa and again before their passengers are discharged in Brazil. A dead female gambiae was discovered after fumigation in a plane arriving in Brazil in October 1941, and two more in January 1942. The original infestation, with all its subsequent miseries, could readily have been started by a single fertilized female. Truly the price of liberty, as far as this malaria-carrying mosquito is concerned, is eternal vigilance."

YELLOW FEVER

Yellow fever, now known to be carried by mosquitoes, was for years one of the most dreaded diseases of the

American Tropics and western Africa. It occasionally extended its ravages into the United States. There were outbreaks in Boston in the seventeenth century and in New York as late as 1856, to mention only two northern localities that have been afflicted with it. New Orleans is in constant danger from it. Asiatic and Pacific regions have, as yet, been free of yellow fever; but, once introduced there, it might spread like a great conflagration.

Unlike malaria, yellow fever acts quickly. A patient either dies soon or recovers. If he recovers, he is usually immune to the disease for at least some years. The fact that during the attack the skin becomes yellow gave the disease its name.

It was formerly believed that yellow fever was spread by contact with a yellow fever patient, his excrements, his vomit, or even with any object that he had touched. As early as the middle of the last century, workers began to suspect that the disease is carried by mosquitoes. Starting about 1881, Dr. Carlos Finlay of Cuba, upheld the suggestion that mosquitoes are the carriers. Working by observation and experiment he had all but proved his case when in 1900 the U. S. Army in Cuba organized a commission to study the infectious diseases there.

The United States commission consisted of Dr. Walter Reed (its head), Dr. James Carroll, Dr. Jesse W. Lazear, and Dr. Aristides Agramonte. They soon abundantly proved that yellow fever is transmitted by a mosquito that was then called *Stegomyia fasciata*, now known as *Aedes aegypti*. They also demonstrated that it is not spread by contact with a yellow fever patient, his excrements or vomit. Volunteers, protected from mosquitoes, lived with yellow fever patients and even slept in beds soiled by the patients without acquiring the disease. Other volunteers, living in clean surroundings apart from yellow fever patients, allowed themselves to be bitten by infected *Aedes aegypti*. These volunteers developed the disease provided the mosquito had some days before sucked the blood of a yellow fever patient.

Dr. Lazear was accidentally bitten by such a mosquito while working in a hospital ward and died of the fever.

There has been much discussion concerning the identity of the organism that causes yellow fever. Whatever it is, it is exceedingly small, so small that it passes through the pores of bacterial filters with the "filterable viruses." Riley and Johannsen (1938, "Medical Entomology") say: "Noguchi in a series of papers presented seemingly definite evidence that the disease was due to a spirochaete which he named *Leptospira icteroides*, but his work met with much criticism, and he himself, before his tragic death in West Africa, came to recognize that he had probably been dealing with a mixed infection or an incorrectly diagnosed case of infectious jaundice and its organism *L. icterohaemorrhagie*."

Although it is now known that mosquitoes of other species, even of other genera, can and do transmit yellow fever, *Aedes aegypti* is directly responsible for most of the trouble in cities.

It is a "domestic" species, breeding in cisterns, water buckets, flower vases and similar containers. Development from egg to adult takes about two weeks at ordinary tropical temperatures. The adult may live for at least five months.

The success of fighting yellow fever in densely populated areas by fighting *Aedes aegypti* was shown by the results in Cuba, in the 1905 outbreak in New Orleans, and in the building of the Panama Canal. However, a new phase of the battle against yellow fever developed. Its history may be told by again quoting extracts from the "Reviews" of the Rockefeller Foundation.

1937

"In the *Review* of a year ago, mention was made of the fact that the epidemiological strategy of the battle with yellow fever had been badly upset by the discovery of the existence of the disease in jungle districts where there were no *Aedes aegypti* mosquitoes. It had previously been assumed that this mosquito was the only carrier and that man was the only natural host. The new picture of yellow fever, therefore, proved to be far darker than had been supposed. It is now known that vast areas of the hinterland of both South America and Africa are endemic centers of the disease. By what vector it travels, other than the *Aedes aegypti* mosquito, or what other hosts there are except man, is not known."

1938

" . . . Clinically, pathologically and immunologically, it has so far been impossible to differentiate jungle yellow fever from the classical aegypti-transmitted variety. Strains of virus isolated from jungle cases differ no more from strains isolated from urban cases than do these latter from each other. Jungle strains can be transmitted in the laboratory by *Aedes aegypti* just as the urban strains can be transmitted by various species of jungle mosquitoes found in Africa and by others found in South America.

" . . . Were it not for the existence of the jungle infection, yellow fever might have disappeared permanently from the Americas in 1934. . . .

"While vaccination promises to be of great aid in preventing the transfer of yellow fever by the human host from one locality to another, it cannot of course eliminate the virus in the jungle nor block its dissemination through contiguous forests in the tropics. Lurking somewhere in these forests are unknown vectors and other hosts than man; and a great deal of work remains to be done before they can be accurately identified."

1939

" . . . Blood tests of wild monkeys show that they are involved in epidemics, but other animals may also play a part. The capture and analysis of thousands of forest mosquitoes during an epidemic showed that three species had yellow fever virus in them, and that two of them could transmit the disease to monkeys by biting. This so-called 'jungle' yellow fever constitutes what may be a permanent reservoir of infection, and vast areas of the South American hinterland are undoubtedly endemic centers of the disease.

"Consequently The Rockefeller Foundation in recent years has shifted its emphasis from temporary anti-aegypti mosquito campaigns in a few of the larger centers to a broader program which includes three principal points:

"1. The permanent prevention of aegypti-transmitted yellow fever through more rigid control measures in urban areas.

"2. The early discovery of such outbreaks of yellow fever as may occur.

"3. The prevention of jungle yellow fever, in so far as possible, through mass vaccination of exposed populations."

1940

" . . . The work of the Foundation in Colombia, South America, in 1940, has thrown new light on this puzzling situation. . . .

" . . . the presence of yellow fever virus was demonstrated in two species of mosquitoes — the *sabethine* [*Sabethes* or *Sabethoides?*] and the *haemagogus* [*Haemagogus*]. In spite of repeated attempts to isolate the virus from many classes of insects, no virus was found in any form of insect life other than mosquitoes.

"The next step was to determine the susceptibility of jungle animals to yellow fever virus. For this purpose over two thousand wild animals were captured. It was found that while the yellow fever virus did not kill any of the animals tested and generally did not produce signs of illness, many species had virus circulating in the blood stream while the animals were running about — a condition especially favorable to the spread of the virus. The tests showed several broad groups of animals, comprising many species, to be susceptible. The chief groups are as follows:

Primates: man and monkeys.
Marsupials: the opossums, all species.
Edentates: anteaters, sloths, armadillos.
Rodents: agouti, paca, capybara, some species of mice.

. . .

"As a result of the several avenues of investigation followed in Colombia, the following tentative generalizations appear to be justified:

"1. Yellow fever is primarily a disease of jungle animals. The classical form involving transmission from man to man by the *Aedes aegypti* mosquito is more of a secondary cycle depending largely upon conditions of population concentration and mosquito breeding created by man himself.

"2. Transmission of jungle yellow fever appears to be by jungle mosquitoes from animal to animal.

"3. There is no animal reservoir of virus in the usual sense. Virus continues to circulate in the blood of susceptible animals for three or four days only, and does not subsequently reappear. Mosquitoes, however, once infected tend to harbor the virus for the remainder of their lives, which may be several months under favorable conditions. . . .

"The discovery that yellow fever can be transmitted in the jungle by carriers other than the *Aedes aegypti* mosquito does not minimize the significant part which the aegypti mosquito plays in the distribution of the disease among human beings. It is not too much to assert that if in urban areas this insect were brought under control as it has been in Brazil, the world could avoid the threat which in these days of fast transit might so easily develop into a cataclysm in East Africa, in India and even in the Orient, to say nothing of parts of the Americas, should the virus of yellow fever break through the barriers of quarantine, vaccination and medical vigilance."

1941

"Continued investigation of jungle yellow fever in Colombia brought added evidence that, in certain areas at least, a *Haemagogus* mosquito is the chief villain in the tragedy. One of the puzzling aspects of this problem has been the complete disappearance of this mosquito at certain periods, especially during the dry season, while at the same time the disease has continued among both animals and men. How could the disease be accounted for in those seasons when the vector supposedly responsible was not to be found? This problem was resolved by the discovery that *Haemagogus* is characteristically an inhabitant of the tree tops and may be found there when it is absent in catches made at ground level. The investigators were forced to develop techniques new to yellow fever work, and as one of them expressed it, it became necessary 'to associate with the monkeys in the interlacing branches high above the jungle floor.'

"With this knowledge available, it was possible to capture haemagogus mosquitoes throughout the entire dry season of 1941, and yellow fever virus was found repeatedly in the mosquitoes caught in the tree tops. An adequate mechanism was thus demonstrated for the carry-over of yellow fever virus from one rainy season to the next, and an explanation was afforded of the known frequency of jungle yellow fever among men engaged in felling trees."

DENGUE

This disease is also called breakbone fever because of the intense pains accompanying it. Fortunately it does not have a high fatality rate, although it is responsible for much suffering and loss of work. It occurs in the tropics and also in the southern parts of Asia, Europe and the United

States. It is carried by at least some of the mosquitoes of the genus *Aedes*, including *A. aegypti*, the urban yellow fever mosquito, and in the Philippines by *A. albopictus*. The disease organism is a filterable virus.

ENCEPHALITIS

Under this heading are included a number of closely related virus diseases that cause enormous losses to livestock each year and may cause outbreaks among the human population. Western equine encephalitis has been known from Kansas and the West for more than fifty years as a disease of horses. St. Louis encephalitis also attacks horses. Eastern encephalitis is a disease of birds. Dr. Wm. A. Davis has shown that various species of *Aedes* are capable of transmitting these diseases and it is possible that certain species of *Culex* may transmit the St. Louis type. These diseases cause deterioration of the brain, the space it occupied being replaced by water. "Sleeping sickness" is the result. When humans contract the western forms of the disease, chances of recovery are rather good, but the eastern form is almost always fatal. Human outbreaks are sporadic and many years may elapse between them.

FILARIASIS

Wuchereria, also called *Filaria*, is a genus of parasitic nematode worms. *Wuchereria bancrofti* is one of the more important species. Its mature stages occur in the lymphatics of man. Embryos ("larvae," microfilariae) live in various of the visceral organs by day or when the patient is active; but at night or when the patient is resting they swarm, often in large numbers, in the peripheral blood stream. If a mosquito such as *Culex quinquefasciatus* sucks blood containing these embryos, the embryos make their way through the walls of the mosquito's body, where they grow and change their form. If at that time the mosquito bites a human, the worms that have reached the mosquito's labium ("lower lip") crawl out and make their way into the human. Their presence in man, especially in the lymphatic system, causes various disorders including enormous swellings of the legs, a condition that is called elephantiasis.

It is worth noting that Sir P. Manson's work on *Filaria* in 1878 was the first demonstration of a parasite being transferred from mosquitoes to man.

FLIES

Among the many species of two-winged insects (Diptera) that are popularly called "flies," *Musca domestica* is the one most often found in man's dwellings. It is *the* house fly. Because it frequently breeds in the excrement of man and other vertebrates, it has been called the filth fly; and because, under certain conditions, it plays an important part in the spread of typhoid and other intestinal diseases, it has been called the typhoid fly. With the pronounced decrease in the number of stables and cow-barns in towns and cities, and with the highly desirable increase of sanitary sewage disposal, the importance of this fly in normal times in North America and in much of Europe has greatly decreased. However, the house fly is a

PLATE 3. A MODEL OF THE HOUSE FLY, *Musca domestica*

real menace wherever there is a relatively dense population of humans living in unsanitary conditions.

Musca domestica never "bites." The biting house fly, also called the stable fly, is *Stomoxys calcitrans*. It somewhat resembles *Musca* but, in addition to more technical distinctions, its beak is sharp-pointed in contrast with the flat-tipped proboscis of *Musca*.

Although horse manure, especially if it be mixed with straw, is the most favorable breeding place for *Musca,* it will successfully breed in any mass of fermenting organic matter. Each female may lay 1000 or more eggs. They hatch in a few hours if the weather be warm. Under conditions favorable to them the larvae (maggots) become full-grown in less than a week and the pupal stage lasts only about four days. Thus, development from egg to adult may be completed in about ten days. Using figures such as these, plus assumptions that no flies die and that favorable breeding conditions are unlimited, calculations are frequently made to determine how many descendants a single pair of flies would have in one season. Such calculations merely show how false the assumptions are.

Musca spreads disease in a mechanical way. An adult fly crawling on, for example, the excrement of a typhoid patient or of a "typhoid carrier" may get typhoid germs on its feet and then, crawling on human food, may leave such germs on the food by simple contact. Or, it may feed on typhoid-laden excrement and later regurgitate its food, germs and all, on our food. Since adults of *Musca domestica* have been found 13 miles from the place where they were marked and released, it is evident that they may be a large factor in the spread of typhoid and other intestinal diseases, including cholera. Adult flies may mechanically spread other diseases such as tuberculosis, anthrax, yaws (a tropical skin disease), trachoma, and possibly leprosy and poliomyelitis ("infantile paralysis"). As to poliomyelitis, *Stomoxys calcitrans* has been more frequently cited as a probable carrier but the question as to which, if either, is an important factor in the transmission of this disease is not yet settled.

As is the case with other injurious insects, the best control of *Musca* and *Stomoxys* is by preventing breeding and this usually requires community action. The proper treatment of manure piles and latrines is not easy. The best advice that can be given here is to secure detailed directions from your State Entomologist and from the Bureau of Entomology of the United States Department of Agriculture.

"Swatting" flies in the house and incidentally smearing their possibly disease-laden fluids on the walls and furniture is not very sanitary. "Sticky fly-paper" is much better. The various sprays may do little more than stupefy flies, after which they should be swept up and killed by burning or otherwise. Since these sprays may contain kerosene or some other inflammable substance such sprays should not be used near an open flame.

Glossina is a genus of blood-sucking flies occurring in Africa and Arabia. They are popularly called tsetse flies.

Unlike most "biting" insects, the males as well as the females suck blood. These flies somewhat resemble large house flies but they are more elongate and have longer wings which give them a parallel-sided appearance when at rest. The mouth parts somewhat resemble those of *Stomoxys calcitrans*. Another characteristic of these flies is that the larvae live in the mother's body. The larvae feed on maternal secretions until they are ready to pupate, at which time they leave their mother's body.

The thing that makes this genus important is that its members are carriers and intermediate hosts of protozoa of the genus *Trypanosoma*. *Trypanosoma brucei* is the organism causing nagana, a very serious disease of cattle and horses. *Trypanosoma gambiensis* is the cause of African sleeping sickness, an even more serious disease of man. The former is carried by *Glossina morsitans* and the latter by *Glossina palpalis* and *G. tachinoides*.

If these flies bite a person having *Trypanosoma gambiensis* in his blood and not more than a few hours later they bite a healthy person they will, by simple mechanical transfer, innoculate the second person. Possibly other biting flies and even mosquitoes do the same. This infectiveness disappears in a few hours but the parasites penetrate the intestinal walls of *Glossina,* and, after a complicated metamorphosis analogous to the transformation of the malarial parasites in a mosquito's body, are ready to enter human blood again.

A satisfactory control of *Glossina* has not yet been developed. Clearing the riverside forests where they live and burning the grass in open places is of local value. Screening of patients to prevent the flies from reaching them seems to have little effect. Possibly wild mammals are reservoirs of infection.

Flebotomus is a genus of minute, biting "sand flies." Although not common in the United States, they are widely distributed and often abundant in the tropics. In addition to the irritation caused by their bites, they are either suspected to be or proved to be carriers of such human diseases as three-day (papataci) fever, kala azar, tropical ulcer, Carrion's disease (Oroya fever or verruga peruviana) and leishmaniasis.

Many of the members of the family Ceratopogonidae, particularly the species of *Ceratopogon* and *Culicoides,* bite human beings. They were formerly included in the Chironomidae but the true midges do not bite although they resemble mosquitoes and are often mistaken for them. Two of the common names applied to the biting midges are punkies and no-see-ums. Their bite is very irritating and they are so small that it is difficult to see them in time to kill them before they bite. Their larvae are aquatic or live in decaying vegetation or between tide zones. It is not known that any of our native species carry disease but several species in the Cameroons are intermediate hosts of a filarial worm in its transfer from man to man.

In some places, species of Simuliidae, the "black flies," are a major pest.

They are active by day and attack both animals and man. Sometimes certain species occur in enormous numbers and bite severely. Since their larvae live in running water, artificial control is practically impossible. Our northern species probably do not spread disease, although certain tropical species of *Simulium* are known to be intermediate hosts of nematode worms living in nodules of the skin of man, causing the disease called onchocerciasis. If the nematode settles in eyes, blindness frequently results. Fortunately, this disease is at present limited to Mexico, Central America and tropical Africa.

The family Tabanidae contains many species variously known as horse flies, gad flies, deer flies and so on. Some species are quite large and none are really small. Only the females bite. It is known that at least one species, *Chrysops discalis,* may transmit tularaemia in a purely mechanical way. West African species *(Chrysops dimidiata* and *C. silacea)* are intermediate hosts of a filarial worm (*Filaria diurna*) causing the disease loa loa.

REPELLANTS FOR PROTECTION AGAINST BITING DIPTERA

Many lotions or ointments have been used to repel mosquitoes, midges and biting flies but none are completely satisfactory, even for a short time. Oil of citronella is an old standby; but many people do not like the odor and prefer the insect bites. "Staway" is a newly developed product that is practically odorless. It possibly affects rayons and should not be used in contact with these fabrics.

The following formula, developed and extensively tested by the Canadian Entomological Branch, is said to give excellent results.

Oil of thyme........ ½ fluid ounce
Concentrated extract
of pyrethrum ...... 1 fluid ounce
Castor oil ...... 2 to 3 fluid ounces

In addition to the above almost any fly spray, and particularly those containing both rotenone and pyrethrum, will give considerable protection. Ordinary kerosene or coal oil will repel pests for some time but the effects are not lasting.

FLEAS

Fleas are notorious chiefly for their bite but some of them carry disease, particularly plague. Typhus also may be carried by fleas but it is more often associated with lice. The eggs of fleas are usually laid on the ground or drop to the ground from the animal on which they have been deposited. The larvae feed on organic debris, often in the cracks of floors or in the nests of the hosts. Pupation takes place there. Adult fleas may live more than two years. The fleas that consistently bite humans in the United States are the dog and cat fleas (*Ctenocephalides canis* and *felis)* and, of course, the human flea (*Pulex irritans*). Other fleas bite man occasionally but do not persist in their attacks.

BUBONIC PLAGUE

Justinian, who ruled the Eastern Roman Empire in the sixth century, is chiefly remembered for the laws that he instituted in the lands over which he ruled; but, despite the great good that he accomplished in bring-

ing justice to the conquered lands, the people suffered greatly from disease. It was during his rule that there was the first recorded great epidemic of bubonic plague. It started in Egypt in the year 542 and spread as far north as Constantinople. It lasted for more than fifty years and resulted in the death of an estimated 100,000,000 people.

The next great outbreak killed about one-fourth (25,000,000) of the population of Europe during the fourteenth century. About two hundred years later an epidemic of plague swept over Great Britain, where more than half of the population died from the disease, there being more than 70,000 deaths in London alone during the years of "The Black Death" (1664-1666). It has been suggested that some of the ancient epidemics of "plague" were typhus, not bubonic plague. The only large, recent epidemic of plague occurred in Manchuria in 1910-1911, resulting in the deaths of more than 60,000 persons; but every year there are numerous isolated cases or small epidemics in various parts of the world.

Bubonic plague seems to be primarily a disease of rats, squirrels, and other rodents. It is a bacterium, *Pasteurella pestis*. Simond showed in 1898 that it is spread from rodent to rodent by fleas. The form of the disease that occurs in rodents other than "domestic" rats and mice is called sylvatic plague. There are three different forms of the disease in man and recovery is frequent only from the form in which the disease is confined to swellings ("buboes") of the femoral and axillary glands. In a second form the bacteria develop in the blood stream, causing secondary pneumonia, which is transmitted from man to man as a result of inhaling droplets ejected by the coughing of a diseased person. A third form, the septicaemic or "fulminating," may develop rapidly from either the bubonic or the pneumonic plague. Death is almost certain to result from either of the last two.

Man may, at least occasionally, contract bubonic plague by contact with rodents that have the sylvatic form or that have recently died as a result of it. Possibly man may also contract the disease as the result of scratching into his skin excrement from some kinds of the fleas that have fed on diseased squirrels or other diseased rodents living in the open country. However, it seems unlikely that epidemics ever start in that way. The blood sucked by a flea and the bubonic bacteria that may be sucked up with the blood in most cases pass through the flea's intestine. The undigested portion of the blood and the bacteria are voided as feces but most kinds of fleas do not regurgitate from the mouth while feeding. This is not true of *Xenopsylla cheopis,* the flea that is often abundant on rats living in human habitations, especially in cities. If this flea feeds on the blood of a rat infected with the bubonic bacterium, a jelly-like mass may form in the flea's alimentary tract in front of the mid-intestine. This mass blocks the alimentary tract so that blood sucked by the flea can not pass into the intestine and be digested. As a consequence, the flea gets very hungry

and is continually trying to feed. Also, while the flea is feeding, the blood that it has just sucked, together with some of the blood from a former feeding, is regurgitated. If this flea with its alimentary tract thoroughly infected with bubonic bacteria regurgitates while feeding on a human, it will infect that person with the plague. When these three things come together—rats infected with the plague, the flea *Xenopsylla cheopis,* and large numbers of human beings—an epidemic of bubonic plague is almost certain to break out. If one of the three is absent, such an epidemic is unlikely and probably impossible. The best safeguard for us is to get rid of rats and other rodents around human habitations.

While rat fleas play the most important part in the dissemination of plague they are not the only carriers of the disease. In 1941, Wheeler, Douglas and Evans demonstrated that the sticktight flea *(Echidnophaga gallinacea)* also carries the disease. The sticktight flea is chiefly a pest of chickens but it also attacks other birds, cats, dogs, rodents, and occasionally man. Birds are not known to suffer from plague but the "sticktight" is found commonly on the burrowing owl and, since this bird is known to be associated with rodents in their burrows, it may play an important part in spreading the disease through the transportation of infected fleas.

THE CHIGOE FLEA

The names Chigoe, chigger (see mites), chique, jigger and sand flea are applied to a flea *(Tunga penetrans)* that has the very unpleasant habit of fastening itself to the human body and burrowing into the flesh. Its favorite places are along the side of or under the toe- or finger-nails, or between the toes; but they may attack any part of the body. It is a very small flea that, because of this habit, causes a great deal of misery to humans but it is not a disease carrier.

It is the female flea that does the damage. She attaches herself and, after feeding, bores under the skin, causing a painful sore or pustule. The eggs are laid while the female is embedded and may remain in the wound or drop to the ground. If they hatch in the wound, the larvae drop to the ground, where they develop in the same way as other fleas.

The Chigoe is found in subtropical and tropical America and Africa. When it infests buildings it may be destroyed by thorough spraying, dusting with poison, or fumigation. Those that have entered human flesh may be cut out and the wound cleaned and dressed; or the insects may be killed by the application of turpentine or other remedies, discharge taking place as a result of ulceration.

THE TRUE BUGS

A great many of the bugs (Hemiptera and Homoptera) will "bite" man occasionally but very few of them are human pests, the best-known being the bedbug. Many small bugs that normally feed on plants, such as leafhoppers and aphids, will quite often take a nip, but these are not bloodsuckers and no after-effects result. Some of the larger bugs that prey

PLATE 4.—A MODEL OF THE RAT FLEA, *Xenopsylla cheopis.*

upon other insects may bite humans if handled carelessly. Only one group, the assassin bugs, is definitely associated with the spread of disease.

THE BEDBUG

There are three kinds of bedbugs that consistently attack man, the common one being *Cimex lectularius*. It is world-wide in its distribution. The other two are tropical or subtropical. (In addition to these, there are a few kinds that attack bats and birds and so closely resemble the ones attacking man that only an expert can distinguish them.)

There is no positive evidence that bedbugs carry disease in nature, but it has been demonstrated that they may do so under controlled laboratory conditions. The general opinion is that, while they are capable of carrying and spreading certain diseases, they do not do so normally and cannot be regarded as carriers.

Bedbugs require about two months to mature during warm weather and apparently do not breed during the cool months in temperate zones. Consequently, there are only two or three generations a year. The fact that bugs of all ages are found at the same time is due to the egg-laying habit, each female laying ten to fifty of her two to five hundred eggs every few days.

During the day bedbugs conceal themselves under folds in bed mattresses and in cracks and crevices in beds, walls and floors, coming out at night for a meal of human blood. When a light is turned on they scurry for cover. If food is scarce, they may travel from one apartment to another and even from one house to another. They are usually carried into the house on clothing or in travelling bags. Railroad coaches, street cars, busses, hotels, cloak rooms and friends' homes may be sources from which the bugs come.

Bedbugs may be controlled by thoroughly spraying crevices in the beds and rooms with odorless kerosene or coal oil. (Be careful of fire.) The efficiency of the spray is greatly increased by the addition of pyrethrum and rotenone.

CHAGAS' DISEASE

Chagas' disease is caused by a protozoan, *Trypanosoma cruzi*, and is transmitted from man to man by species of *Triatoma*, *Mestor* and *Rhodnius*, all members of the Assassin Bug family. These bugs are also known as kissing bugs and cone-noses, the latter because of the shape of the head. They comprise a group that has apparently changed from a predaceous, insectivorous habit to one of sucking vertebrate blood. Some related species that do not persistently suck blood may do so at times.

The trypanosome undergoes changes when swallowed by the bug; but the disease is apparently not transmitted by the bite of the insect. The insect usually defecates while or immediately after feeding. The trypanosomes in the insect's intestine are carried in the insect's excrement and may enter the body of man as a result of the person scratching or licking the sore caused by the bite of the bug.

Chagas' disease was originally recognized in Brazil in 1909, where it was quite prevalent, especially among

young children. It is frequently fatal. It has since been found in other tropical American countries and as far north as the southern United States.

In addition to spreading the disease, the insects may cause severe illness as a direct result of their bites. They apparently inject a specific poison that causes a burning sensation, intense itching and much swelling. In addition to the original focal swelling, red blotches may develop on various parts of the body. The effects may last for weeks, although they usually disappear within a few days. Bites from some of the species may cause nausea, palpitation of the heart, rapid breathing and other symptoms which are also evident in Chagas' disease but uninfected bites are not fatal.

A northern species of Assassin Bug that sometimes bites humans is the Masked Bedbug Hunter, the young of which are usually covered with dust. They feed on bedbugs but, as they feed also on other household insects, their presence does not necessarily mean that bedbugs are in the house.

LICE

True lice, not plant lice, are wingless insects of the order Anoplura, also called Siphunculata. They are probably related to the true bugs. All of them live on and suck the blood of mammals. The Head Louse of man *(Pediculus humanus* or *capitis)* may be the same species as his Body Louse *(Pediculus corporis* or *vestimenti).* The latter is also called Cootie and Grayback. The Crab Louse of man is *Phthirius pubis.*

The control of lice attacking man may be accomplished by personal cleanliness; fumigation of living quarters, bedding and all clothing by chloropicrin ("tear gas") or some other effective fumigant; sterilization of clothing and bedding by steam or air at 140° for twenty minutes, or by ironing them slowly with a hot iron; use of mercuric chloride for destroying pubic lice; and use of kerosene for the killing of head lice. Since some louse-borne diseases can be transmitted by crushing infected lice between the fingers, this means of control is dangerous.

TYPHUS FEVER

Other names that have been applied to the disease that is now generally known as typhus fever are ship fever, jail fever, war fever, Brill's disease, tabardillo, murine disease and spotted fever. It should not be confused with typhoid fever. The disease organism is a bacterium, *Rickettsia prowazeki.* One of the symptoms of typhus is a blotching of the skin; but since similar spottings are caused by other diseases, the name "spotted fever" for typhus is confusing. The name "murine disease" alludes to the part that rats and mice have in the spread of typhus.

Rats and mice are subject to typhus. Apparently fleas, especially *Xenopsylla cheopis,* transmit the disease from rodent to rodent and also from rodent to man. Lice of the genus *Pediculus* are apparently the principal — possibly the only — carriers of typhus from man to man. The disease enters the human system either when an infected louse bites the person or when the feces of an infected louse or the crushed body of an infected louse is rubbed on a scratch

or other break in the skin of the person. After a louse has bitten a typhus patient a period of seven to eleven days must elapse before the crushed body of the louse can transmit the disease but it may be transmitted by the louse's feces after as few as three days. Development of the disease in humans requires ten or twelve days.

The disease is milder in children and an attack results in immunity, which may explain the apparently low incidence of the disease among peoples who are normally infested with lice. Outbreaks of typhus are common among soldiers and in concentration camps because the crowded and often unsanitary conditions in camps favor the increase of lice. The control of rats and of lice means the control of typhus. The recent development of a vaccine for innoculating against typhus may greatly reduce the danger of the spread of the disease.

TRENCH FEVER

Trench fever is carried by lice in the same way as is typhus fever but there is a great difference in its symptoms. There is no spotting of the skin; the disease may last for two or three months; and no immunity is produced. The onset of the fever after infection by crushed lice occurs in from five to twenty days; but if the infection occurs from the louse's excrement the fever develops in eight days. It is not known how much time must elapse after feeding upon a victim of trench fever before crushed lice can produce the disease in man but the feces are capable of doing so after five days.

Trench fever is not a dangerous disease, but it may be responsible for great loss of manpower. Those suffering from it often are very slow in regaining their strength and may be absent from duty for three or four months. It was only during the first world war, that the disease became well known and was studied by both British and American commissions established for that purpose. Almost all that we know about the disease is the result of the investigations of these commissions. It is impossible to determine the number of cases that occurred during the first world war because thousands of cases of influenza were diagnosed as P.U.O. (pyrexia of unknown origin) before it was discovered that two diseases were concerned. The name trench fever did not come into use until the disease itself became common.

EPIDEMIC RELAPSING FEVER

This type of relapsing fever is spread solely by lice, chiefly as a result of scratching by an individual who has crushed lice. The spirochaete causing the disease develops in the liquids and organs within the body-wall of the louse but is unable to survive long in the intestine. The disease is not common but is liable to appear in epidemic form. It is easily controlled by the elimination of lice.

TICKS AND THEIR RELATIVES

Insects never have more than three pairs of jointed legs; and the head of an insect is not immovably joined to the thorax. Scorpions, spiders, mites and ticks have four pairs of jointed legs (at least when adult) and the head is immovably joined to the thorax. Scorpions have a segmented abdomen. Spiders and mites, including ticks, have

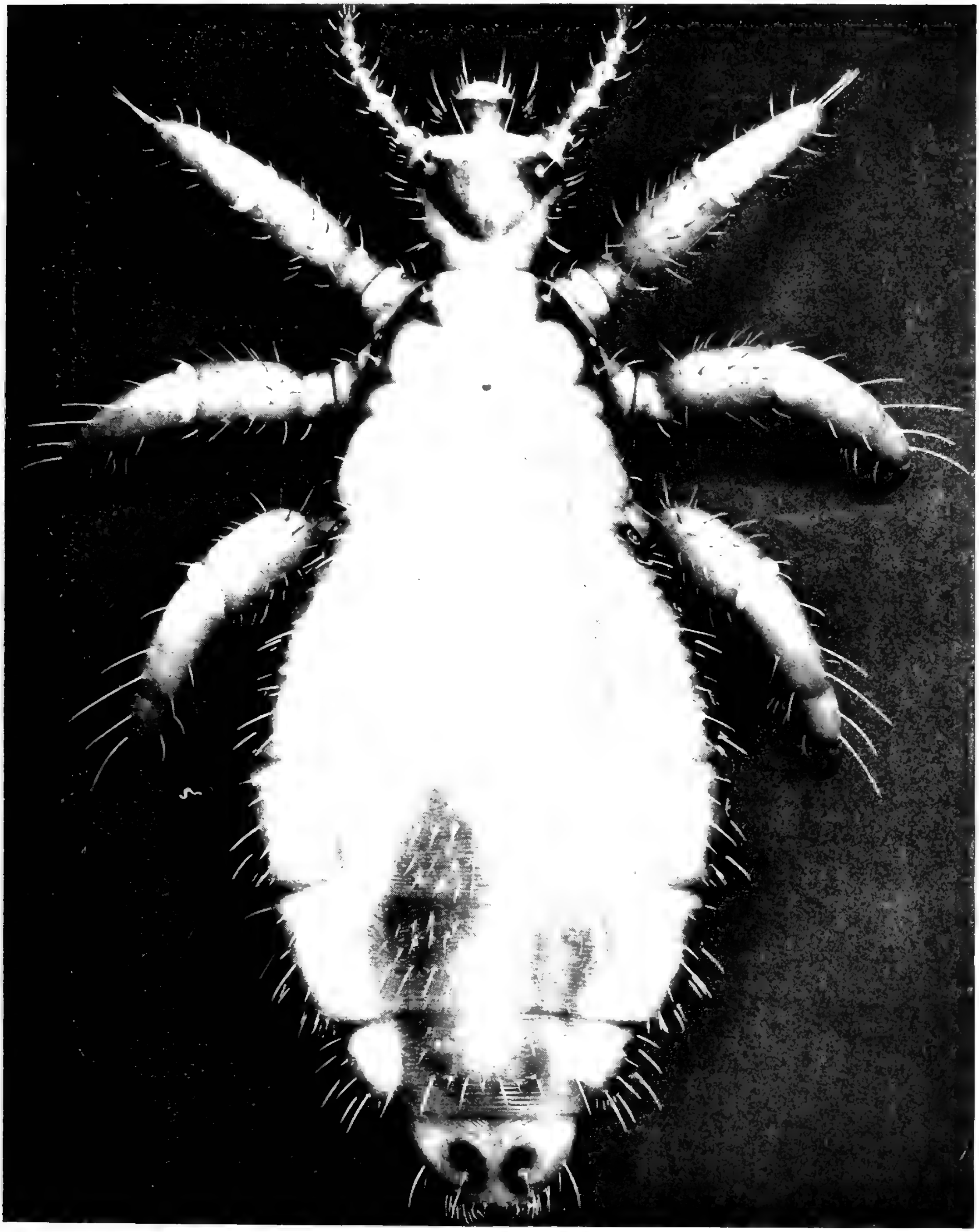

PLATE 5. — A MODEL OF THE BODY LOUSE, *Pediculus corporis*

the abdomen unsegmented. Spiders have a definite constriction in front of the abdomen; ticks and other mites have the abdomen more broadly joined to the rest of the body. Ticks are classed as a superfamily (Ixodoidea) of the order (Acarina) of mites. The distinctions between ticks and the other mites are rather too technical to be given here.

TICKS

Ticks are parasitic on vertebrate animals, including man, and may prove to be among the most important carriers of diseases to man and domestic animals.

The life history of the various kinds of ticks follows the same general pattern but there is a very great difference in the time required to reach maturity. Some kinds complete their life cycle in less than a year, while others require up to four years. A single female may lay as many as 18,000 eggs; three or four thousand is a common number. Newly hatched ticks may live for about four months without feeding, and nymphs and adults may starve for more than a year. The six-legged larvae or "seed-ticks" hatch from eggs on the ground and attach themselves to some animal. Some kinds remain on the animal until mature but most of them, after feeding for from a few hours to a week or more, drop to the ground to molt. After molting they again attach themselves for feeding or they may hibernate. In all, there may be from three to eight molts (depending on the species) before the adult stage is reached. Attachment occurs primarily for the purpose of feeding; however, some kinds also mate on the host.

Ticks present a very different appearance before and after they have become engorged with blood. Before feeding, the tick is round or ovoid in outline and quite flat or a little convex above and concave below. Its legs are conspicuous. When it has become engorged it may be five or six times as long, the body is rounded, and the legs are relatively small. As the blood is digested the body becomes smaller.

"The best way to remove a tick, and this should be done without delay, is to take hold of it with the fingers and pull it off slowly with a firm straight pull without jerking" (Herms). If care is not used, the head may break off and remain in the wound.

ROCKY MOUNTAIN SPOTTED FEVER

Tick fever, black fever, blue disease and black measles are other names of this disease. It has been known in the Bitter Root Valley of Montana since 1872 but, despite its name, it is not restricted to the western mountain areas. In the East it is most prevalent in Maryland, Virginia, and North Carolina. Parker states that it is present in at least 39 states; and since 1931 it has been reported from 26 of the eastern and central states. The virulence of this fever varies greatly in different parts of the country. In southern Idaho the mortality is only 1% to 3% of the victims, in California about 16%, and in eastern Montana very much higher. The outbreak of a rash on the wrists, ankles and sometimes on the back, later spreading to all parts of the body, is one symptom and explains the descriptive name "black measles."

Proof that Rocky Mountain spotted

fever is carried by ticks was furnished by McCalla and Brenton in 1905, although Wilson and Chowning had advanced the theory three years earlier. Wolbach discovered the disease organism *(Rickettsia rickettsi)* in 1919 and named it in honor of Dr. Ricketts, whose work in connection with Rocky Mountain spotted fever and typhus was outstanding. Dr. Ricketts died from an infection during his researches on typhus in Mexico.

Rocky Mountain spotted fever occurs in rabbits and other rodents and is transmitted from rabbit to rabbit by the rabbit tick *(Haemaphysalis leporispalustris)*. This tick does not bite man and therefore does not transmit the disease to humans. The ticks that do transmit the disease both from rodent to rodent and from rodent to man are (more or less in the order of their importance) the Rocky Mountain spotted fever tick *(Dermacentor andersoni)*, the American dog tick *(D. variabilis)*, the Pacific Coast tick *(D. occidentalis)*, and the brown dog tick *(Rhipicephalus sanguineus)*.

Ticks may become infected with *Rickettsia* during their first meal or during any future meal. Once infected, they are capable of transmitting the disease during their entire lifetime; and the females can even transmit the disease to their offspring through the eggs. Because the immature stages of ticks feed particularly on rodents, cats, dogs, etc., almost the whole source of human infection is the bites of adult ticks.

The disease passes the winter in ticks that are either in the adult or nymphal stage. Parker states that the bite of an infective, over-wintered tick in the early spring may not produce recognizable infections but may produce an immunizing attack of the disease. Later in the season bites become more dangerous, the disease becoming more severe as the result of warm weather. However, since the adults of *D. andersoni* dislike hot weather, they usually seek cover under grass by the first of July, after which time there is very little danger of being bitten by this species. In sections of the country where other species of ticks capable of transmitting the disease are active during the summer months, the danger of infection is present at all times.

Fortunately, an infected tick does not transmit the infection until it has fed on its "host" for from about two to ten or more hours. Consequently the danger of infection is slight if attached ticks are removed within a few hours. One usually becomes aware of a tick crawling on the body or trying to insert its mouthparts, but ticks may very often become attached without the knowledge of the victim and they may remain for a considerable time before they are detected. It is therefore advisable for those in tick-infested areas to examine themselves thoroughly on returning from the fields or woods. Oddly enough, it is usually men who acquire Rocky Mountain spotted fever in the West, where *D. andersoni* occurs; but it is usually women in the East where the dog tick is the vector.

General control measures against the Rocky Mountain spotted fever tick have not been satisfactory and the safe thing is to keep out of tick-infested areas during the dangerous part of

the year or to wear clothing that will make it difficult for the ticks to reach the body. A vaccine has been developed by the U. S. Public Health Service for protection against the fever. It gives protection for at least one season but it is less effective as the season progresses and the virulence of the *Rickettsia* increases.

TICK PARALYSIS

Tick paralysis is rather prevalent and there are numerous cases each year. It is rarely fatal to humans. As far as is known, it is caused only by the Rocky Mountain spotted fever tick and its occurrence therefore coincides with the distribution of *D. andersoni.* The exact cause of the paralysis is not known but it is believed to be due to a salivary secretion that is injected by the tick into the body of the person upon whom it is feeding.

Children seem to be particularly susceptible to tick paralysis. In one of the early cases reported in Oregon by Temple in 1912, the patient after retiring the preceding night in healthy condition was unable to stand in the morning, and by the third day the paralysis was so complete that the child was unable to speak or eat. The removal of two engorged ticks resulted in complete recovery within a week. After removal of the ticks the patient usually recovers fully within a day or two.

In most cases of the disease the engorged ticks have been discovered on the nape of the neck or along the spine, these being the favorite places of attachment for this species of tick. Recovery may take place naturally when the ticks drop off; but, on the other hand, death may result if a number are present and the paralysis is prolonged.

COLORADO TICK FEVER

This fever occurs in many parts of the Rocky Mountain region and results from the bite of the Rocky Mountain spotted fever tick *(Dermacentor andersoni).* It is painful and debilitating, but not fatal. The disease organism is not known.

RELAPSING FEVER

Relapsing fever has been known in Africa for about a hundred years; but it was not until 1904 that Ross and Milne definitely showed that the disease is tick-borne. As early as 1857 David Livingston reported upon the evil effects following the bite of a tick that was later named *Ornithodoros moubata* by Murray (1877). It is said that the natives of Central Africa have long dreaded the bites of ticks.

The disease organisms of relapsing fever are various species of the bacterial genus *Spirochaeta.* Possibly they are merely forms of one species, *S. duttoni* or *S. recurrentis.* It occurs on all of the principal continents and, wherever found, is transmitted by ticks of the genus *Ornithodoros.* In the United States it is confined to the Southwest and to altitudes above 3000 feet in our western mountains, the regions occupied by *Ornithodoros turicata* and *O. hermsi* respectively. The natural "reservoirs" of relapsing fever in the United States are squirrels and other rodents.

When infected blood is taken into the body of a tick the Spirochaetae bore their way through the walls of the digestive tract and into apparently

all parts of the tick. Those that reach ovaries innoculate the eggs of the tick and the infection is passed on to the next generation. Some reach the tick's salivary glands and others the coxal glands (glands at the bases of the tick's legs). Those that reach the salivary glands are injected by the tick into the wound caused by its subsequent feeding. Probably those that reach the coxal glands may enter the human body through a break in the skin. There is a case on record in which a man contracted the disease directly from a squirrel by accidentally smearing his fingers with its blood.

TULARAEMIA

This is primarily a disease of rabbits but it has been found in other wild animals, including coyotes, sheep and quail. It severely attacks man also. The disease organism is a bacterium, *Pasteurella tularensis*. It is widely distributed in the United States. The rabbit tick, *Haemaphysalis leporis-palustris,* is largely responsible for its distribution from rabbit to rabbit, although the rabbit louse, *Haemodipsus ventricosus,* also is a vector. Probably transmission of the disease occurs whenever blood from an infected animal is transferred to a susceptible one, including man. When the disease was first recognized in 1919 it was called deer fly fever because it was found to follow the bite of a species of deer fly, *Chrysops discalis.* People who shoot rabbits or prepare them for cooking are in danger of becoming infected by the blood of diseased ones coming in contact with a scratch or other break in the person's skin.

OTHER MITES

Many kinds of mites other than ticks may occasionally bite human beings, but only a few kinds consistently attack man. Although not carrying a disease, some of them may be considered to be themselves a disease.

SCABIES

This disease, also called mange and itch, is a very small, almost colorless mite, *Sarcoptes scabiei,* that bores under the skin, particularly where it is delicate, making tunnels that may exceed an inch in length. Since the life cycle is completed in about two weeks and each female lays fifteen or twenty eggs, a single female gaining entrance under the skin is soon responsible for an extensive sore, the skin becoming irritated by poisons given off by the mites. Scratching results in bleeding and often increases the irritation. In addition, scratching may spread the mites to other parts of the body.

This mite occurs also on swine, horses, cattle, dogs, and probably on other mammals. Outbreaks on man can often be traced to some individual who has been in contact with mangy domestic animals. In peace time its presence on man is usually of local distribution, although whole families or school districts may be affected. During war, when people may be crowded together unduly, it may become very prevalent and movements of infested people may carry it into districts that were formerly free from it.

The treatment now recommended in England, where extensive tests have been conducted because of the great menace of infestation during war con-

ditions, is 18% of sulphur incorporated in a bland soap and applied to the body in a lather that is allowed to dry. About three applications in four days often results in a complete cure. The British distribute the medication in what they call "sulphur lather tablets." Although these tablets are not currently available in the United States, the treatment was originally developed here by Dr. R. A. Nolan.

CHIGGERS

Harvest mites, red bugs, or chiggers are often the cause of much suffering by those who find it necessary to be in the fields during the summer and autumn. These mites should not be confused with the Chigoe flea, sometimes called chigger.

The chiggers attacking man are the larvae of mites belonging to the family Trombidiidae and especially to the genera *Trombicula* and *Eutrombicula*. The adults are large mites, sometimes being as much as half an inch long, and vary in color from light to dark red. The nymphs and adults are believed to feed on decaying vegetation in the soil, but the larvae are predaceous upon various kinds of animals, including snakes. The eggs are laid in the soil. The young larvae make their way to the surface and crawl up on grasses, weeds, or other low foliage, where they lie in wait for a victim.

When the chigger has become attached by means of its sharp mouthparts it remains for two to three days. Within a few hours the area surrounding the mite becomes reddened, quickly swells, and later develops into a water blister. Even before the swelling occurs there may be intense itching. Scratching increases the irritation. On man the mites usually attach themselves in places where the clothing fits tightly, such as beneath a belt or garters, but they may be located on any place on the body. When present in large numbers there may be a slight fever but the chief unpleasantness results from the intense irritiation and the resulting lack of sleep.

Chiggers occur throughout the temperate and tropical regions, less abundantly in the north. There is no control, but some protection may be obtained by changing clothes immediately after returning from the field and taking a hot bath with plenty of strong soap lather. Tall weeds and grass harbor large numbers of the mites and these areas should be avoided if possible. Sprinkling flowers of sulphur or pyrethrum on the body under the clothing is said to give some protection. The internal use of sulphur, which is exuded in perspiration, also has been recommended.

The itching caused by the mites may be alleviated by the use of a paste made with bicarbonate of soda or by dabbing the itching spots with rubbing alcohol or ether. "Lather-less" shaving creams are recommended both as a preventive and to lessen the itching.

RAT MITES

Rat mites *(Liponyssus)* are extremely small creatures that act in the same way as chiggers. They are to be found in buildings and are often the cause of considerable discomfort to man. While the swellings produced are much smaller than those caused by chiggers,

they are equally as irritating for several hours. The mites attack both rats and mice and frequently become abundant in their nests. The control of these rodents will eliminate the mites but it may be several weeks after the destruction of the rodents before the mites disappear.

SPIDERS AND SCORPIONS

The universal fear of spiders and scorpions has little basis in fact, for these creatures play a relatively minor role among the arthropod pests of man. Unlike some of the mites which are true parasites, these animals are accidental attackers. Occasionally they injure man directly by injecting venom into his body. Although much still remains to be learned about the exact virulence of some of the incriminated arachnids it is certain that the great majority of spiders and many scorpions are harmless. Their venom has been specialized to kill insects and other invertebrates for food and is, with several notable exceptions, relatively impotent when introduced into the bodies of warm-blooded animals. As far as is known, these arachnids do not transmit diseases of man.

THE VENOMOUS SPIDERS

The average spider bite produces a painful sensation comparable to that of some of the biting flies, and there follow slight local reactions at the site of the punctures. Only a few species from among many thousands secrete a venom which, differing qualitatively, is capable of producing serious neurotoxic symptoms and rarely even causes death.

Most of the largest and seemingly most formidable of all spiders, the tarantulas or bird-spiders, are considered to be relatively innocuous. A few of the American species have been singled out as being possible exceptions but as yet too little is known about their actual virulence. Species of a related family found in Australia, *Atrax robustus* and *formidabilis* of the Dipluridae, seemingly possess a venom that is highly neurotoxic and is capable of causing systematic distress comparable to that of the notorious "black widow" spider.

A considerable number of true spiders have been accused of being venomous through prejudice or circumstantial evidence, but few have been demonstrated by modern investigators to be truly dangerous. The famed European tarantula *(Lycosa tarentula)* is now known to be a relatively harmless creature.

The most notorious of all the venomous spiders are the species of *Latrodectus*. Found in temperate and tropical regions throughout most of the world, the various species have been justly regarded by many different peoples as being especially dangerous. The "Malmignatte" of southern Europe, the "Katipo" of New Zealand and the "Black Widow" of the United States are shining black spiders, strongly marked with red. Other species, such as the "Knobbie Spiders" of South Africa, are less brightly colored, but the venter is always marked by an X-shaped paler maculation, the "hourglass."

Probably the best known species of the genus is the black widow *(Latrodectus mactans)*, found throughout a

large part of North and South America. This spider spends most of its life in a coarse, irregular web located in burrows, crevices, or recesses under rocks or trash. The disturbed and littered areas around man's homes and outbuildings are favorable situations, and not infrequently these spiders are found in the buildings themselves. Bites occur when man accidentally brushes against or squeezes a spider and the creature instinctively bites and injects venom until it is free to run away. Following the injection of venom, come sharp to excruciating muscular pains accompanied by nausea, profuse perspiration, difficulty in breathing, and other symptoms. In the average case the severe symptoms abate within a few hours and normality is attained within a few days. Relatively few people die, as is indicated by Dr. E. Bogen, a foremost authority on the medical status of the bite, who stated that "I am unable to find more than twenty deaths in the past four hundred years due to the Black Widow."

Treatment of black widow bite consists for the most part of measures to relieve the pain (sedatives, hot baths, intravenous injection of epsom salts) during the severe stage. Do not use alcoholic drinks or stimulants. A specific anti-venom has been used successfully.

Ordinary insecticides are not recommended for the eradication of venomous spiders. Within limited areas of infestation, such as around and in outbuildings and homes, a systematic search for the spiders and their destruction individually is preferable to general fumigation.

THE VENOMOUS SCORPIONS

The poison gland of the scorpion is located in the specialized last segment of the post-abdomen, and the venom passes through a curved spine or sting. Most species are able to break the skin of man and cause a more or less painful injury, but in general the effect may be described as negligible. However, as in the case of spiders, a very few scorpions have a venom which differs in quality from that of most of their kin, one which sometimes causes severe symptoms or death. Also, as in spiders, the dangerous scorpions are of relatively small size.

A number of virulent scorpions occur in northern Africa, of which *Prionurus australis* and *Buthus occitanus* are perhaps the most important. An effective scorpion anti-venom has been developed. In the Americas there are several species which have come to be regarded as dangerous. The best-known species is the Durango scorpion of Mexico *(Centruroides suffusus)*, which is reputed to cause more deaths each year than the black widow spider. Most of the deaths occur in children under ten years of age. The symptoms include numbness following the sting, then itching of the nose and throat, excessive production of saliva, a gradual collapse and waves of convulsions, following which comes gradual recovery or possibly death. Treatment for the sting includes sedatives, hot baths, and the use of a serum. A similar species of scorpion *(Centruroides sculpturatus)* occurs in Arizona and is reported to have caused twenty-five deaths from 1929 to 1938, chiefly in children.

Universe through a Microscope

THE PROTOZOA

by Roy Waldo Miner

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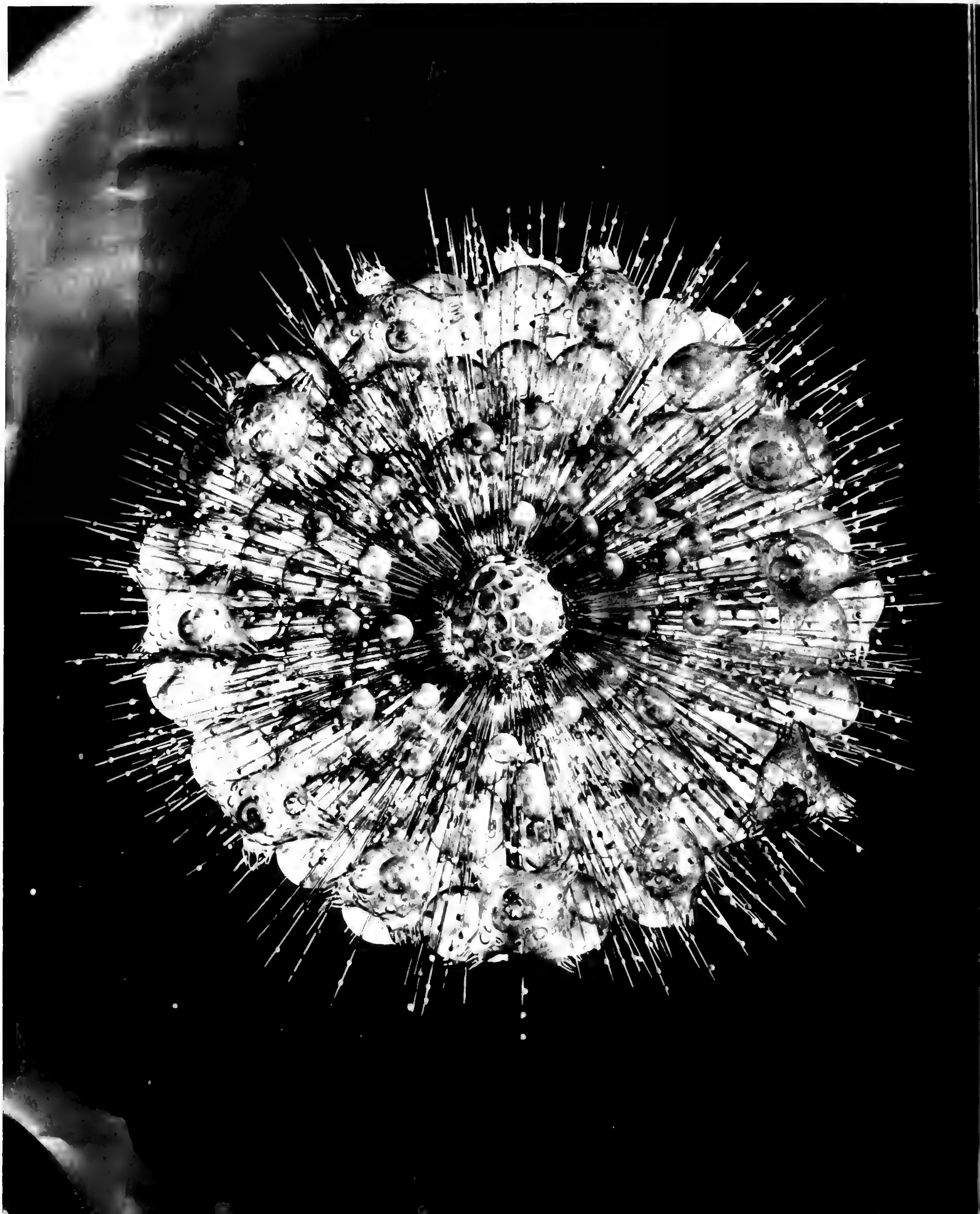
▼ A MINUTE SEA CREATURE (*Trypanosphæra regina*): one of the Radiolaria. These tiny animals construct a skeleton of natural glass from the silicon dissolved in sea water. The nucleus, which directs the life-activities of the creature, is contained within the latticed sphere in the center. The photograph is of a glass model representing the animal highly magnified, constructed by Herman Mueller, the Museum's skillful glass-modeler



Universe Through a Microscope
The *Protozoa*

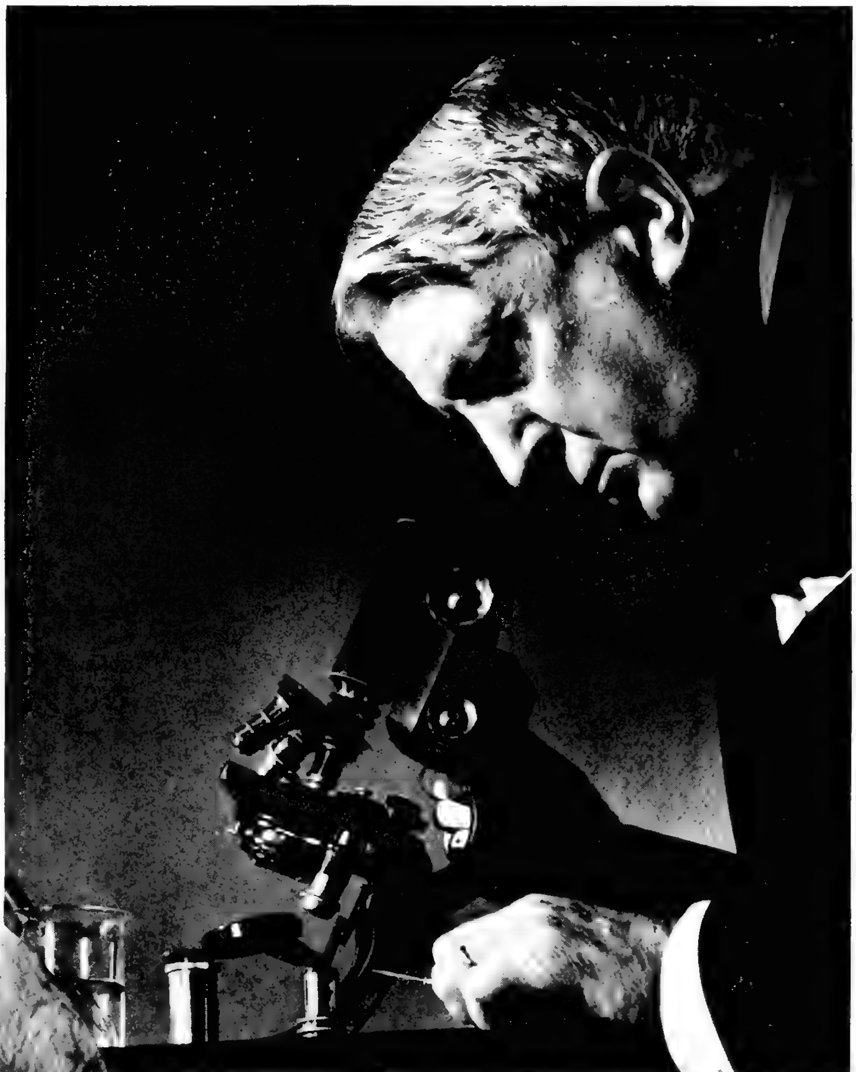
By Roy Waldo Miner
Curator of Living Invertebrates, The American Museum of Natural History

Tiny creatures that swarm by the million in water everywhere. A world invisible to the naked eye but of great importance to mankind

Photographs by Charles H. Coles, *American Museum*

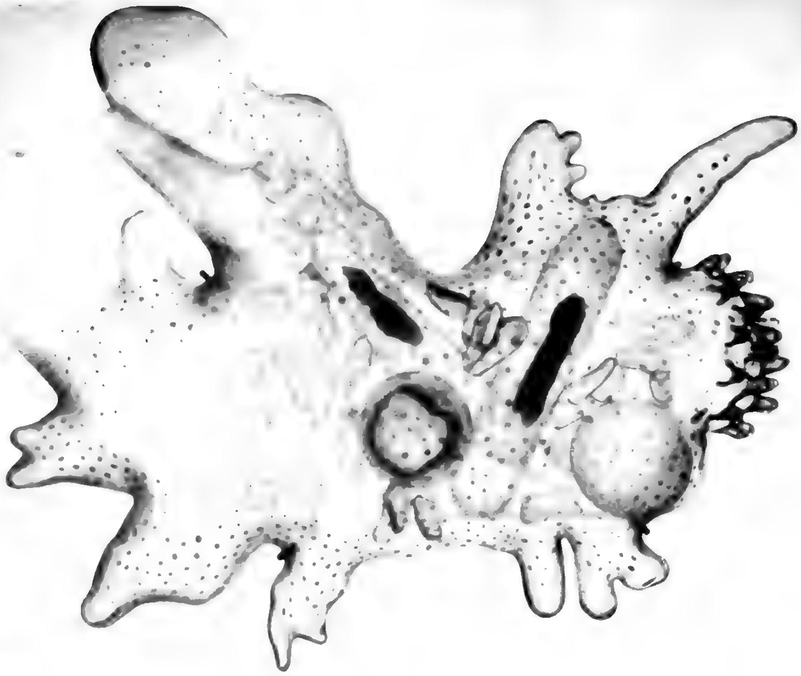
In this world of struggle between millions of human beings, it is hard to realize that, invisible to our eyes, another world composed of billions of organisms is pulsing with complicated life activities in our very midst and carrying on a struggle that has continued through eons of time since long before man, or, in fact, all other animal life, came into existence. The invention of the microscope, three centuries and a half ago, created a window through which the great naturalists of that time were able to peer into this universe of minute creatures hitherto totally unsuspected by mankind.

Conspicuous in this microscopic life are the teeming Protozoa. With their minute bodies consisting of but a single cell, they were among Nature's first experiments in animal life. Yet the ancient trial was a success, for they still live and penetrate all the zones of existence. They inhabit the earth from the equator to the arctic regions, from the highest mountain tops to the deepest abysses of the ocean. Wherever there is moisture they exist, and, in their resting stages, they bide their time in desert places. They swarm over aquatic vegetation and multiply in pond and stream. They float in the open ocean by myriads



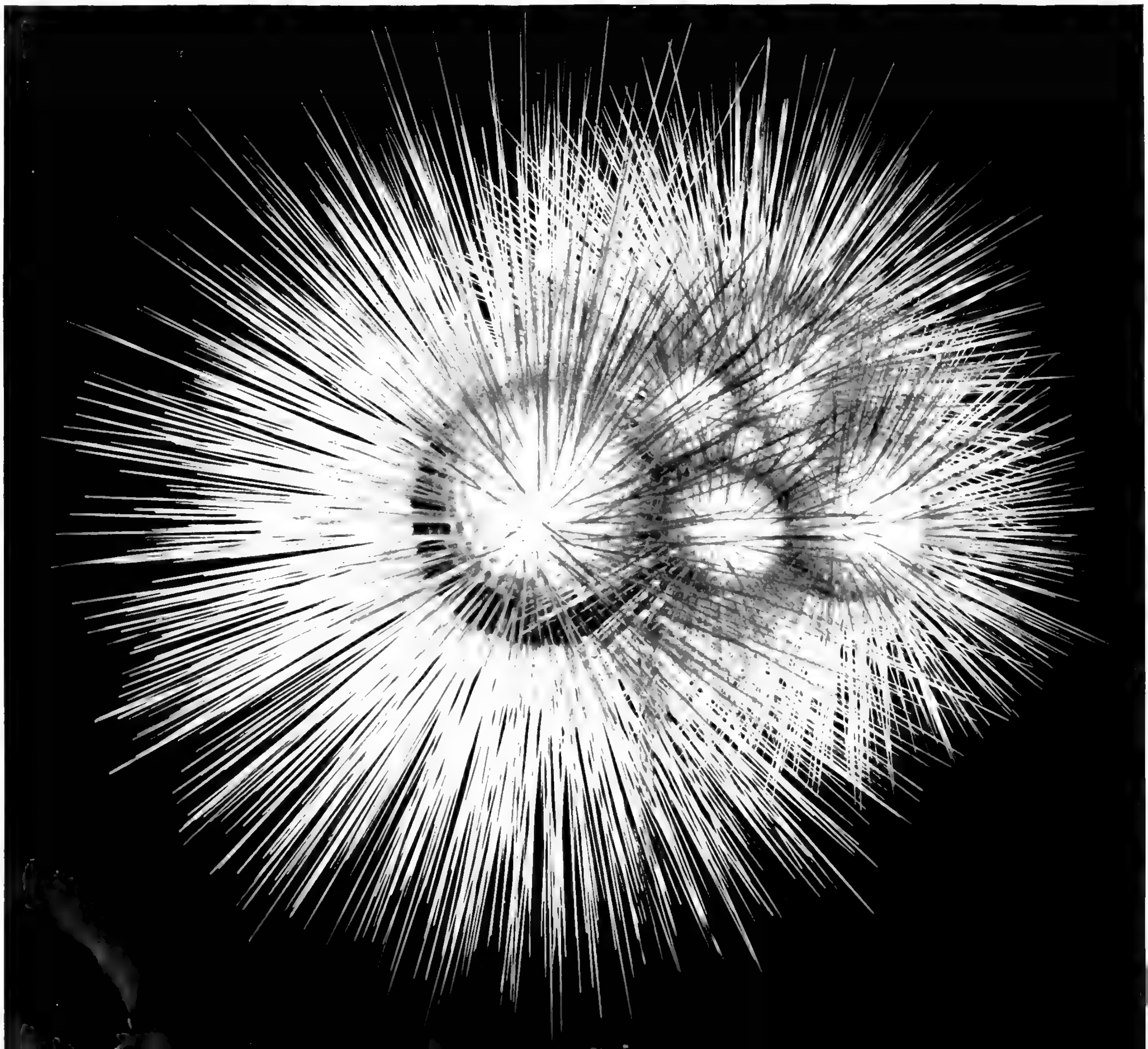
▲ Looking through the microscope into an otherwise invisible world, Doctor Miner selects the tiny creatures from which greatly enlarged models are to be constructed in glass for the American Museum's exhibit of Protozoa. Each animal must be carefully studied and drawn before this is possible. Skilled artists are used for this purpose

◄ Herman Mueller, the Museum's wizard in glass, exercises his remarkable skill in modeling countless delicate structures over a hot flame to produce his wonderful protozoan models

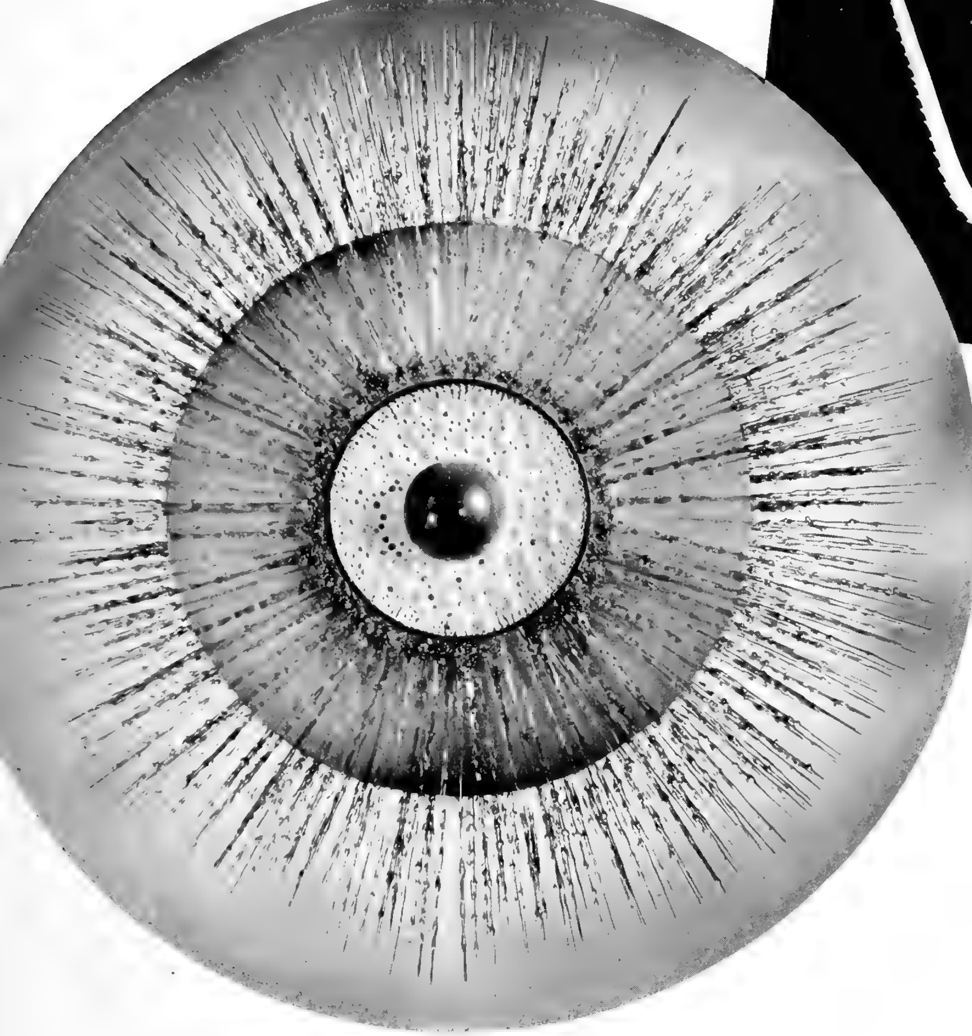


◀ One of the simplest of all living animals, the microscopic single-celled *Amoeba* resembles an irregular mass of living jelly, moving about by extending finger-like projections of its substance and flowing into them. The round nucleus is visible near the center of the body. A bubble-like "contractile vacuole" at the right is about to expel detritus into the surrounding water. This model, like the others, is of glass and represents the animal highly magnified. The *Amoeba* is common in fresh water

▼ Unlike the related naked *Amoeba,* the *Globigerina* builds a many-chambered shell of limestone. These creatures are so numerous, floating in the open sea, that, when they die, their shells gradually accumulate on the sea bottom, forming beds miles in extent. These often solidify into rock. Geologic changes may elevate them above the surface to form limestone cliffs like those of Dover, England. Thousands of related species are known, which build shells in great variety of pattern. Many are fossilized, and among them are certain species found only in oil-bearing rocks, so they are of importance to oil geologists as aids in locating oil deposits. Note the great number of delicate needle-like bodies that had to be set carefully in position on this model



➤ **The protozoan** ***Ceratium,*** **with its peculiarly shaped glassy shell, is particularly abundant in tropic seas, where, at night, the luminescent bodies of these tiny creatures cause the sea to glow in the foaming wake of moving vessels, or when the water is disturbed by oars**



▲ **This beautiful creature is among the simplest of the Radiolaria. Whereas most species of the group are equipped with glassy shells, the** ***Actissa princeps*** **is shell-less. The spherical nucleus is centrally located within the membrane of the central capsule, while threadlike pseudopodia ("false feet") extend in all directions to secure food**

and their fossil shells form the substance of continental rocks. Finally, they penetrate the tissues of all other animal life and gain their livelihood in the intestines and blood stream of the highest animals, including man. While carrying on this part of their career some feast upon man's very tissues and organs, causing many of the most serious of his diseases and culminating in epidemics more fatal than war. Who knows but that Nature's first life experiment may well be her last and that the legions of primitive one-celled creatures that achieved the earliest steps in evolution may finally triumph over the boastful race that fondly imagines it has achieved the summit of evolution, namely, Man himself?

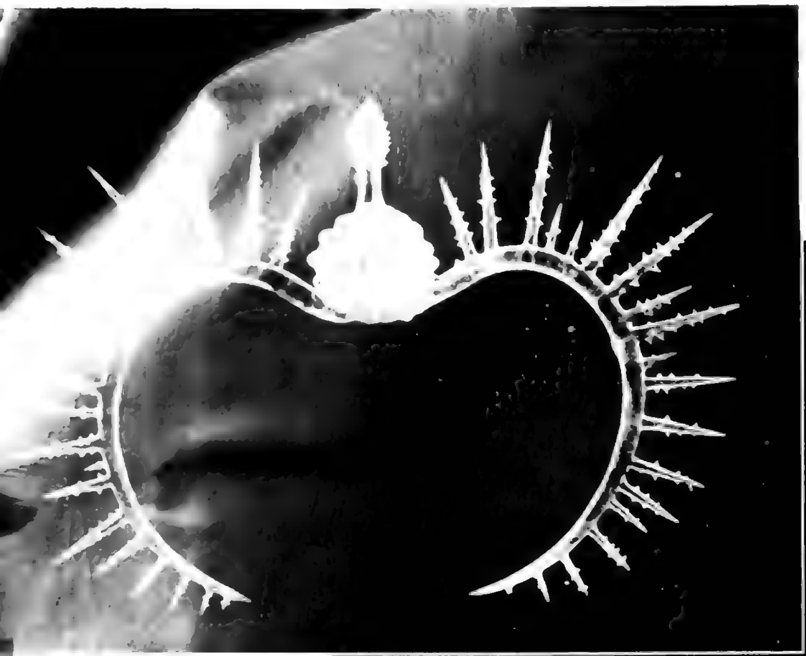
The Protozoa are spoken of as *single-celled animals.* That is, their entire bodies are equivalent in size and living substance to one of the millions of microscopic cells that make up the tissues constituting the organs of our bodies. But there the resemblance ends. For each protozoon is a complete and independent animal, performing within its minute single cell all of the functions that require our entire cellular complex to accomplish.

Within the protoplasm enclosed by its cell boundaries, the protozoon provides for sensation, locomotion, feeding, digestion, assimilation, growth, breathing, excretion, and reproduction. Our enormous equipment of cells is made up of specialized individuals arranged in tissues, which, in turn, are grouped in organs, each with a special function. A muscle cell can do nothing but contract. A digestive cell can only secrete. A nerve cell can only transmit sensory or motor impulses, and so on, all other functions being lost or reduced.

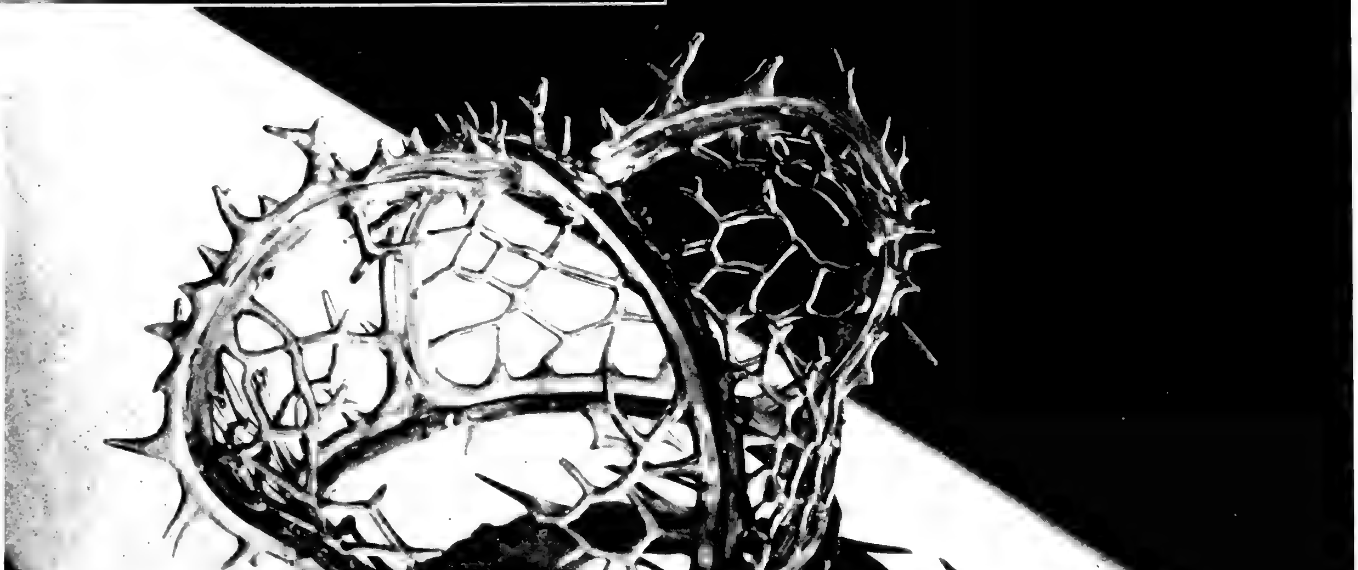
A cell is thus a living protoplasmic entity. In many-celled animals (Metazoa) it is the living unit of structure, while in single-celled animals (Protozoa) it is the entire living organism. The protoplasmic substance of the cell consists of two main portions, the nucleus and the cytoplasm. The former is a rounded, ovoid, or sometimes variously shaped body of greater density than the cytoplasm. It controls the activities of the cell, including the reproductive function. The cytoplasm is the clearer substance composing the rest of the cell, containing various bubble-like vacuoles having to do with digestion and excretion, as well as other inclusions of varied significance to the cell.

The Protozoa are divided into four main groups, which, however, blend at their boundaries through intergrading types, thus showing their fundamental relationship. These are the Rhizopoda, Mastigophora, Sporozoa, and Ciliata.

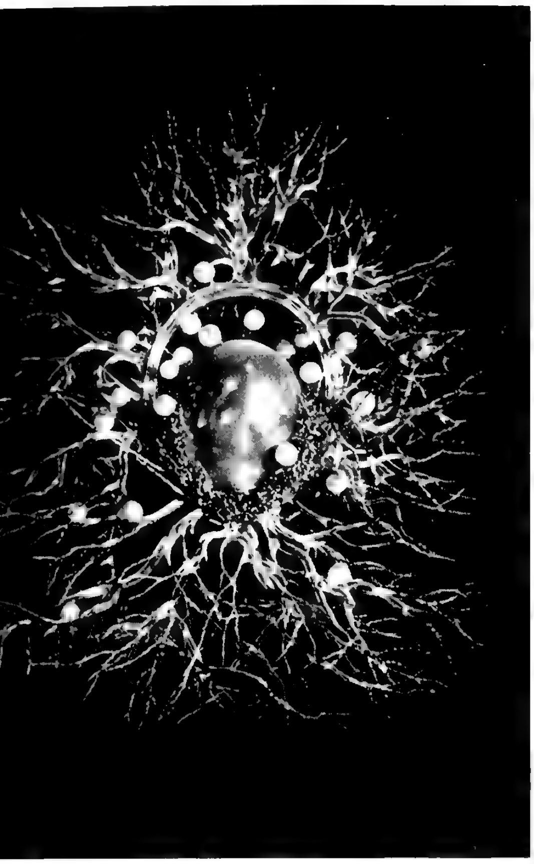
The Rhizopoda have bodies without regular shape from which they extend club-shaped or threadlike portions of their substance and flow into them in order to move from place to place. They also utilize these projections to secure their prey, which they engulf at any part of their body surface. They may be naked or equipped



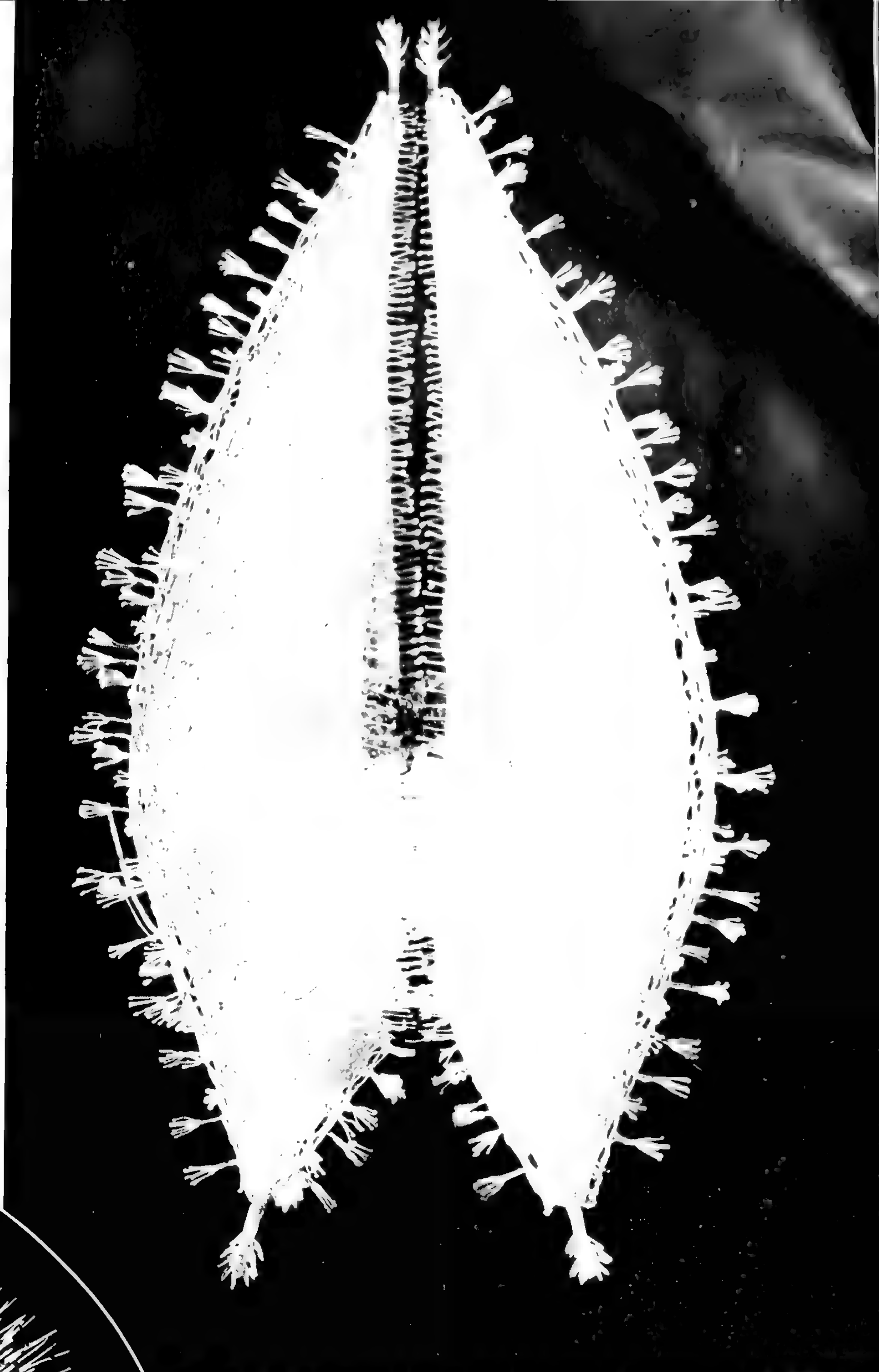
RADIOLARIA produce an almost infinite variety of shell forms. *Dorcadospyris dinoceras,* at left, though a gem of microscopic beauty.possesses a pair of menacingly spiked horns, as its scientific name indicates, that would be terrible if borne by some gigantic prehistoric monster. Actually, the creature is only about the size of a sand-grain

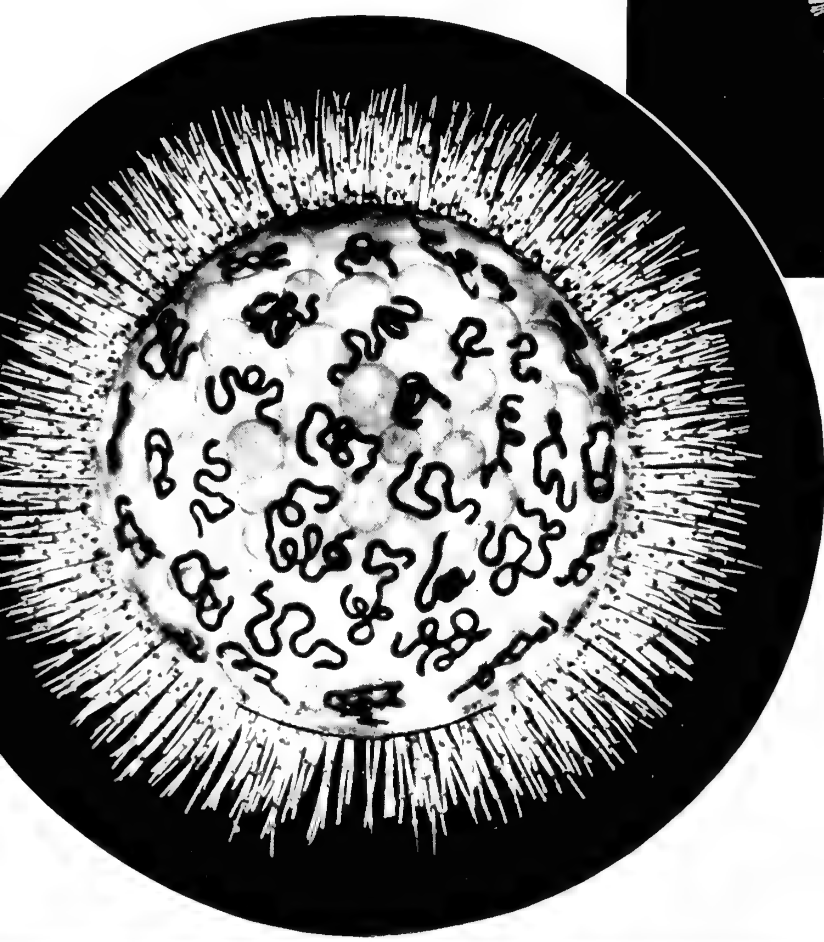


▲ MANY OF THE RADIOLARIA achieve patterns of extraordinary beauty in their crystal shell formations. *Acanthodesmia corona,* though almost literally a "crown of thorns," as its name indicates when translated, has shaped its glassy spikes into a graceful diadem. The models shown here are all on display at The American Museum



THIS is one of the most remarkable of the adiolaria. *Lithocircus magnificus* has formed a ertical crystal hoop, with branching treelike ntlers extending in all directions. The rose- olored central capsule housing the nucleus is eated in this frame, showing a curious cone- haped structure through its transparent wall

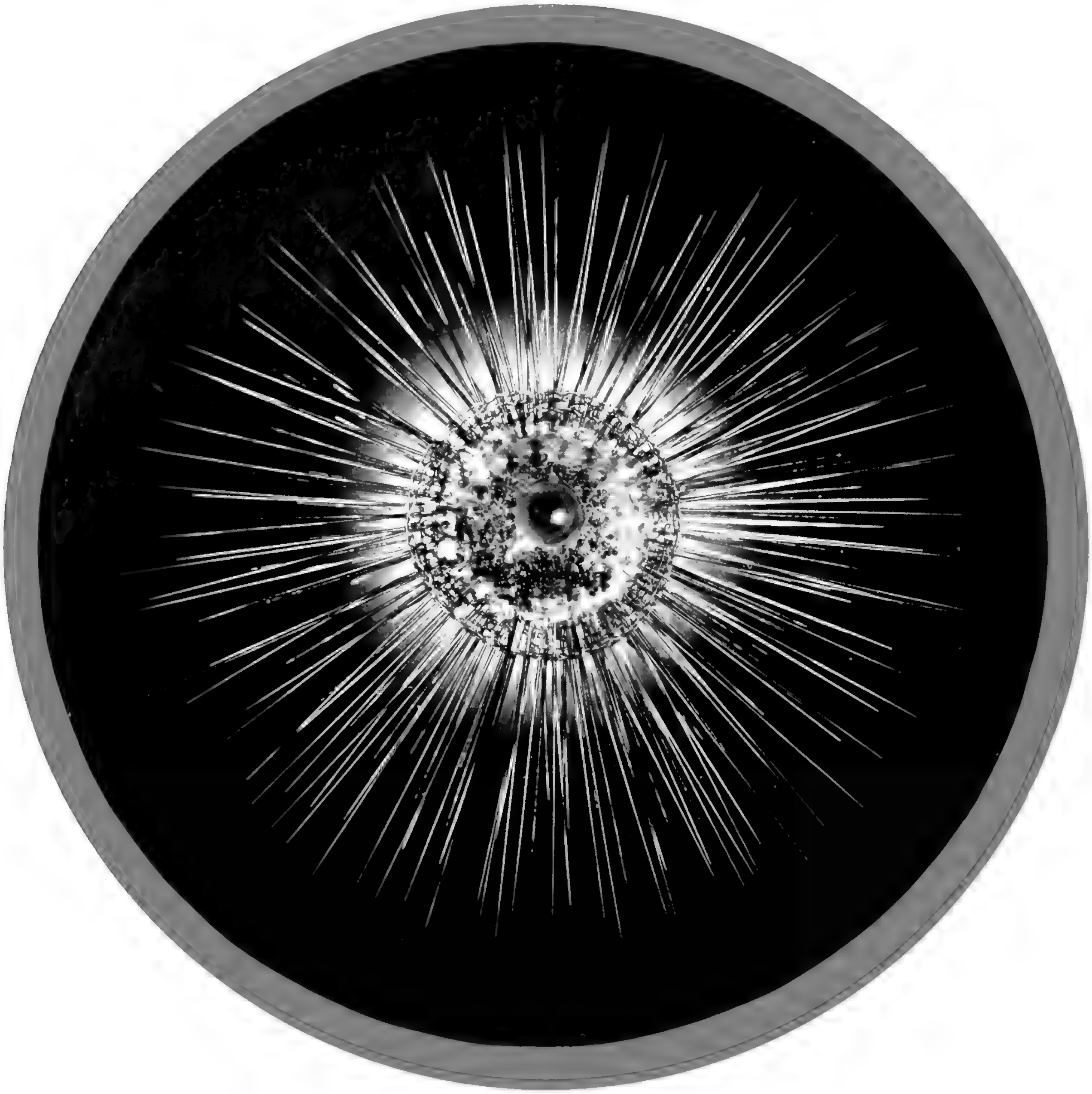




▲ THIS SPECIES *(Coelographis regina)* might well be called the "Queen Radiolarian." It is one of the most highly specialized forms of the group. Between its graceful mitre-like shells is enclosed a complicated central capsule with branching tubelike structures, while the outer surface is a delicately wrought mosaic of lace-work. Incidentally, this is a triumph of glass-modeling technique, being one of the most difficult of Herman Mueller's achievements

◀ THE SERPENTINE RADIOLARIAN *(Collozoum serpentinum)* is a colonial species, made up of many individuals, each with a scarlet, serpent-like nucleus. They surround a central bubble-like mass from which the protoplasmic filaments of the colonial pseudopodia project in all directions

▼ THO[illegible] the Queen Radiolarian, nevertheless the [illegible]*gonia* is of good size, being 1/8 of [illegible] inch in di[illegible]ter. It is enclosed in an almost perfect sphere of glass lacework made up of multitudes of hexagonal meshes. It is found floating in abundance at the surface in the tropical Atlantic



with shells of tectin, carbonate of lime, or silicon. Some of these are simple, while others have successive chambers arranged spirally or otherwise. Many show delicate and complex patterns.

The Mastigophora ("whip-bearers") are distinguished by a usually more definite body form, and by one or more flagella, or flexible whips, with which they lash the water and thus move rapidly from place to place. Some form colonies, while others are parasites, causing diseases dangerous to higher animals and man.

The Sporozoa are internal parasites on larger animals. They are of simple form and reproduce by means of multitudes of spores. Hence the name. Some of these also are the source of serious human diseases.

The Ciliata are so called because their bodies are covered with numerous closely set cilia, or hairlike projections, much smaller than flagella, but, like them, used for propulsion. They have a more complicated nuclear apparatus and much more specialized structure than the other groups. They are mostly free-swimming organisms and, in certain species, reach a higher degree of unicellular specialization than any other Protozoa.

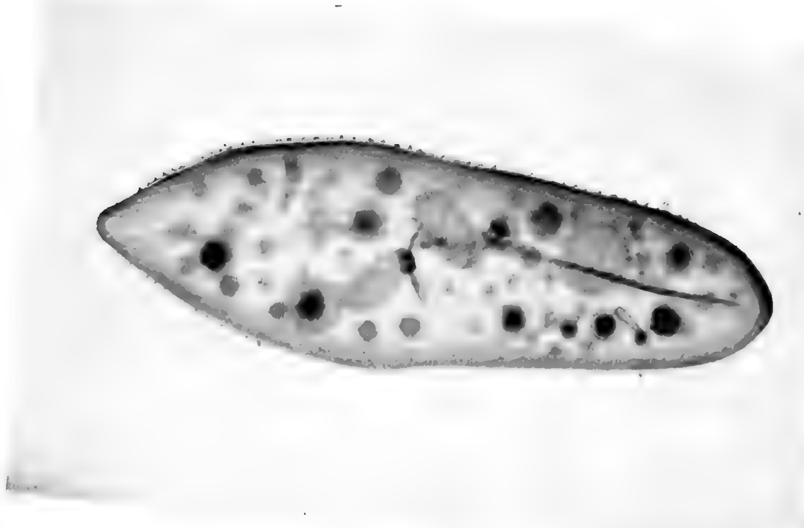
Each of these four groups has followed its own particular road of evolution, starting with comparatively simple types that show evidences of relationship to the other groups and then evolving more specialized forms peculiar to each group.

Among the displays in the Darwin Hall of the American Museum of Natural History, there is an alcove devoted to the Protozoa, in which may be seen a series of glass models accurately portraying these organisms on a highly magnified scale, beautifully wrought by the Museum's skillful glass modeler, Herman Mueller, many of them under the writer's direction. Outstanding examples of his work are depicted in this article.

Here, some of the most typical Rhizopoda are shown, beginning with the primitive *Amoeba* with its naked irregularly shaped body, through the transparent walls of which may be seen the oval nucleus, the bubble-like contractile vacuoles, the food vacuoles, and other internal features. The Foraminifera have bodies like *Amoeba,*

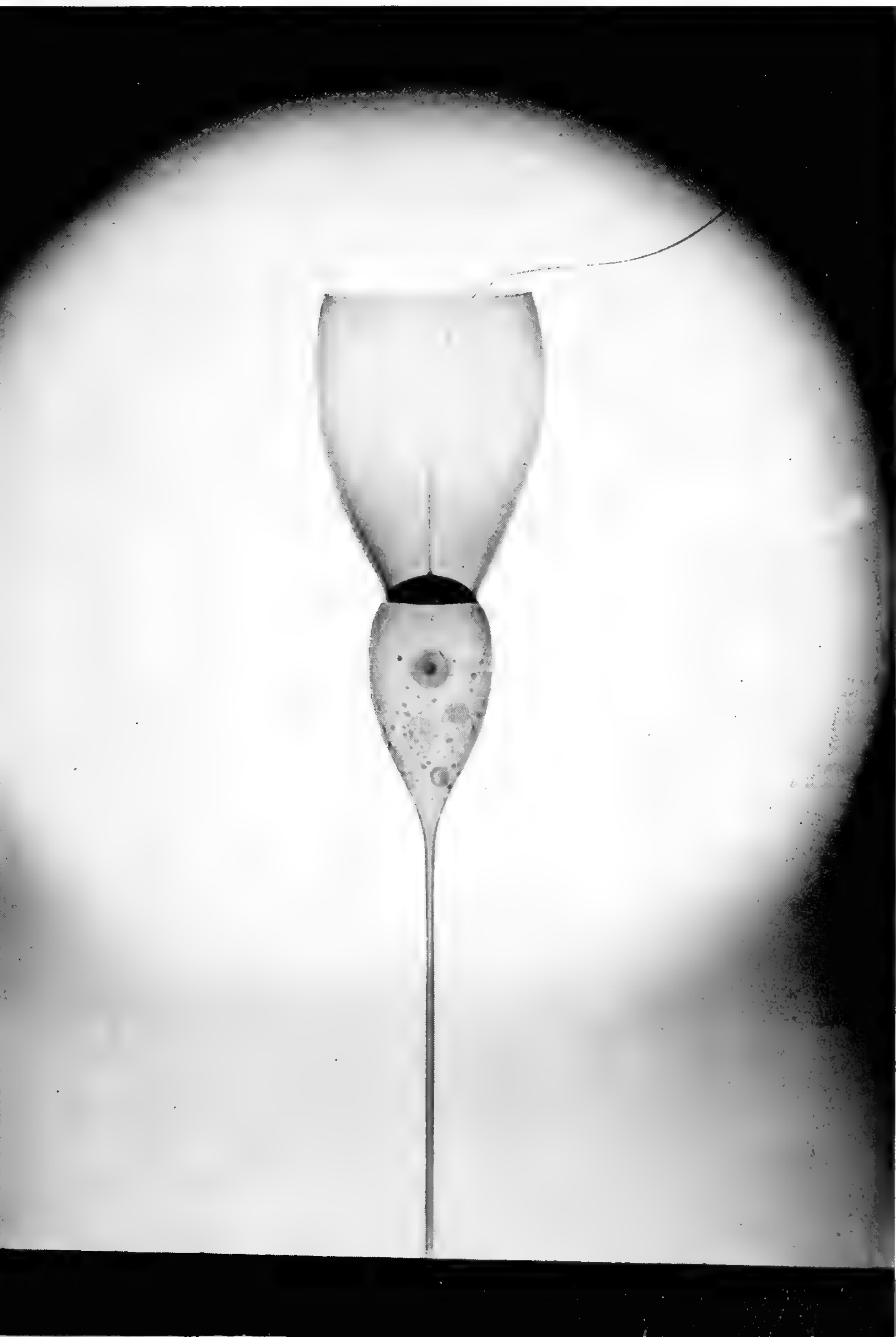
but equipped with protective shells of limestone, the most conspicuous of which (*Globigerina bulloides*) is represented by a beautiful model. This organism floats by the million in the open ocean and, when it dies, its tiny spiral and spiny chambered shell sinks slowly with thousands like it to the sea-bottom, where they accumulate as Globigerina ooze in banks hundreds of feet in thickness and many miles in extent. During past ages, many of these banks have hardened into rock and, in some cases, through geologic changes, have been raised above sea-level to form continental limestone cliffs. The chalk cliffs of Dover, England, were formed in this way.

Other microscopic marine creatures of tropic seas are the Radiolaria. These manufacture their lattice-like "skeletons" from natural glass, i.e., silicon, with a chemical formula closely akin to that of opal. They are wrought into patterns of unbelievable delicacy and beauty. A fine series of glass models in the alcove exemplifies the intricate variety of these. Like their lime-producing relatives, the glassy skeletons of the Radiolaria are extensively deposited in beds of siliceous ooze on the ocean floor, forming a fine, flinty sand, which, under the name of Barbados earth, is used by jewelers as an abrasive for polishing and grinding precious stones.



▲ *Paramecium caudatum* is a member of the numerous and specialized ciliate protozoans. Its body is shaped for rapid motion, being propelled by multitudes of tiny hairlike cilia, which cover its surface

▼ THE GOBLET-CELL *(Monosiga gracilis)*: one of the Whip-bearing Protozoa, or Mastigophora. Its long, slender whip is here surrounded by a thin goblet-shaped membrane. The threadlike stalk anchors the creature to the pond bottom



The radiolarian animal, like the other rhizopods, extends pseudopodia from all parts of its body, radiating like delicate filaments to form a trap in which other organisms are caught. These are entangled by the filaments, which surround them with protoplasm and draw them toward the central organism, digesting them as they do so. The radiolarians are also complicated in having an oval central capsule within which the nucleus is contained. Foamlike bubbles between the protoplasmic threads have a hydrostatic function, enabling the animal to expand along the radiating bars of its glassy skeleton, thus reducing its specific gravity, so that it rises toward the water-surface, and sinks again upon contracting.

Some of the Radiolaria enter into an extraordinary partnership with tiny globe-shaped organisms belonging to the group Mastigophora, scattered throughout its foamy body. These are yellow in color, due to chlorophyll, which enables them to form their food in the presence of sunlight from carbon dioxide excreted by their animal-feeding partner. In this process, they

release oxygen which, in turn, is needed by th [illegible]

T [illegible] Cili[illegible]a are found both in fresh a[illegible] [illegible]ater [illegible]ke the Rhizopoda, [illegible]ve a [illegible]te body form and [illegible]tside [illegible] covered with close-set [illegible]or small hairlike struc- [illegible]ating in unison, like tiny [illegible] drive the creature through the [illegible]ter. In the various species, there is a great variety of shape as shown by the ciliate models in the alcove. One species (*Paramecium caudatum*), familiar to students, is streamlined like a submarine boat and has an equipment of multitudinous moving hairs arranged spirally, so that the animal [illegible]otates as it swims. Larger cilia, fused together in groups, line a shallow but [illegible]ually deepening trough (cytostome), the cell's equivalent for a mouth, and create a current in the water, which drives smaller protozoans, diatomes, and food-particles generally down through a tubelike "gullet," at the internal end of which a bubble forms to receive it. This "food vacuole," by means of fluid ferments, digests the prey while moving along the streaming currents of the internal protoplasm. Ciliata also have two nuclei, a larger and a smaller one. In many cases, highly specialized structures within the cell (organelles) perform special functions foreshadowing the many-celled organs of higher animals. In fact, some species of this group are considered to be the most highly organized of the Protozoa.

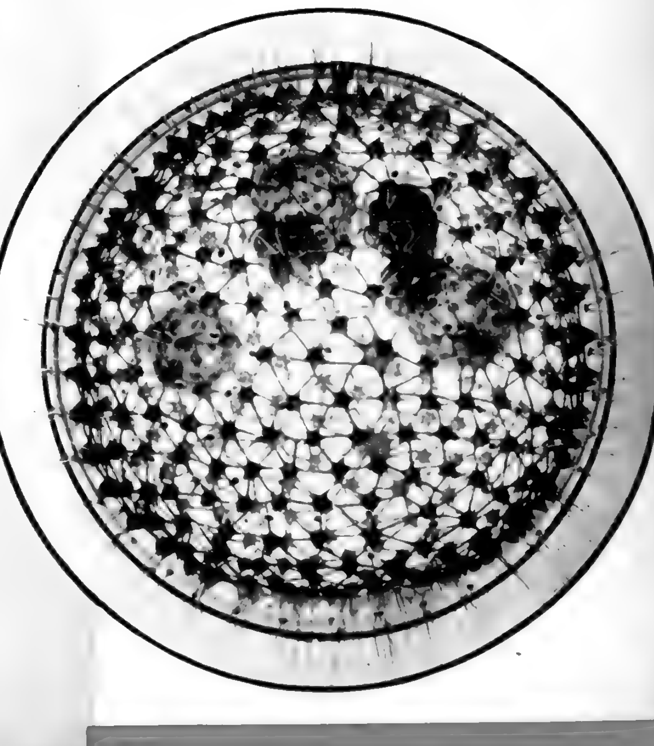
The Mastigophora start off with species of simple organization having changeable amoeboid bodies like those of the Rhizopoda, but, nevertheless, furnished with a whiplike flagellum for propulsion. Most species, however, possess a definite body form without cilia like those of the Ciliata, but with one, two, or several long flagella which propel them through the water.

Some have a cytostome ("mouth") at the base of the flagellum, through which small organisms are taken into the interior. Others have no mouth, but, within the body, there are green, brown, or yellow structures equipped with chlorophyll, thus enabling them to obtain their food, like plants, in the presence of sunlight. This difference in feeding, which, in higher plants and animals, is so clear a distinction between the two great kingdoms, is here a matter of variation in related groups. So that, in this group of one-celled organisms, one may look for the first divergence between the Animal and Plant Kingdoms.

Some of the Mastigophora (Choanoflagellata), possess a delicate, transparent, collar-like structure around the base of the flagellum, which aids in food capture. Such species are often anchored to some object by means of a slender stem and so are stationary. In others, these stems are united to each other so that the individuals form a

◄ THE PROGENITOR INDIVIDUAL of this colonial "family tree" ***(Stylobryon petiolatum)*** has died, leaving its goblet-shaped house behind. Its four children have anchored their homes on the rim of the parental edifice and may be seen as tiny "collared animalcules" through the transparent walls of their dwellings. To the rims of these, in turn, are attached their offspring of the second generation, which have budded from their own parents, in the manner seen in the "house" of one of their own companions. A fourth generation has been added, and a fifth has started. The animal at upper left has suddenly divided into multitudes of spores

▼ *Volvox globator*: a remarkable colony of 1200 or more members, described in the text



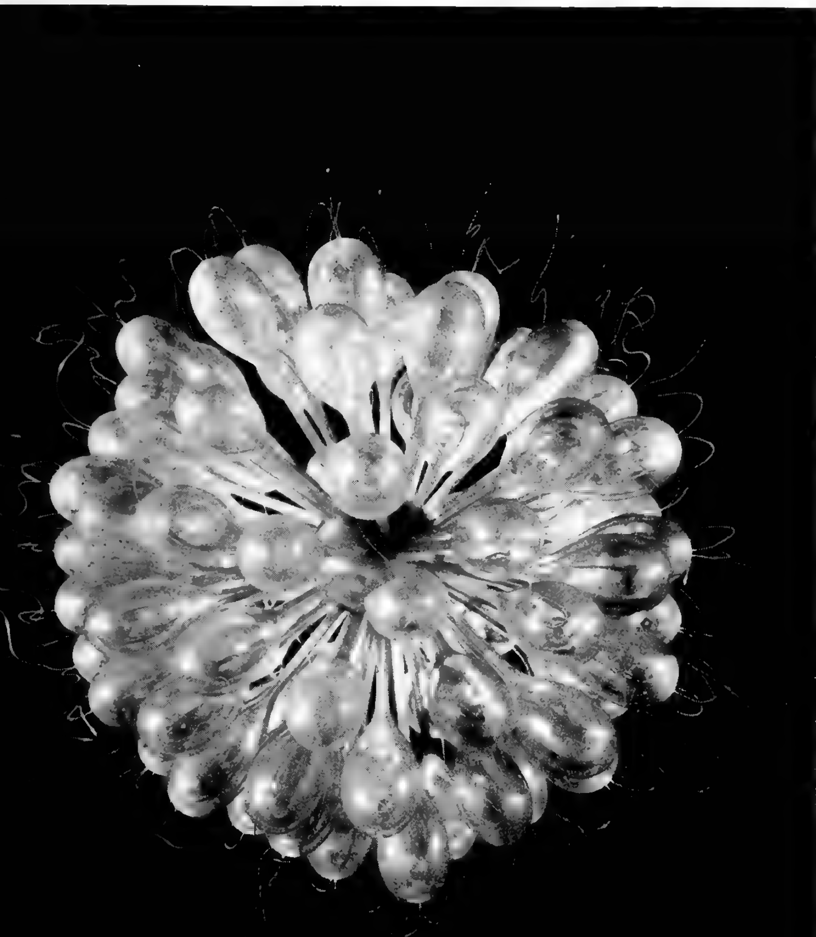
group or colony, which may be either fanlike or united in a spherical cluster of many similar individuals. In the case of the species *Volvox,* there are a thousand or more individuals united to each other by a network of protoplasmic strands around a hollow sphere, each member of the colony possessing two flagella, by the combined motion of which, the colony rotates through the water.

It would be hard to say, at first glance, whether *Volvox* is a colony of single-celled organisms or a single many-celled organism, were it not that the various individuals are capable of existing independently at certain times, while, in many-celled organisms, the cells are dependent upon each other for their existence, being fundamentally specialized structures. Strange to say, there is a foreshadowing of specialization even in *Volvox.* For certain members of the colony become larger than the rest and sink into the interior of the spherical colony, dividing rapidly as they do so, until they form new miniature colonies like that of the parent. Eventually these break through the parent wall and swim away independently. These organisms, therefore, illustrate a method by which many-celled animals and plants may have been evolved from the Protozoa.

Among the Mastigophora are certain tapering organisms, swimming about by means of an erect "undulating membrane," which inhabit the blood of higher animals and man. These are known as *trypanosomes.* Some of them are apparently harmless, but others devour the blood cells and tissues, causing such diseases as African sleeping sickness. Another flagellate is responsible for the disease known as kala azar. Both of these are fatal to man, while related forms cause great depredations among cattle and other mammals. Protozoans of these groups pass part of their lives in insects and are transmitted to the higher animals by biting or, in some cases, by their excrement.

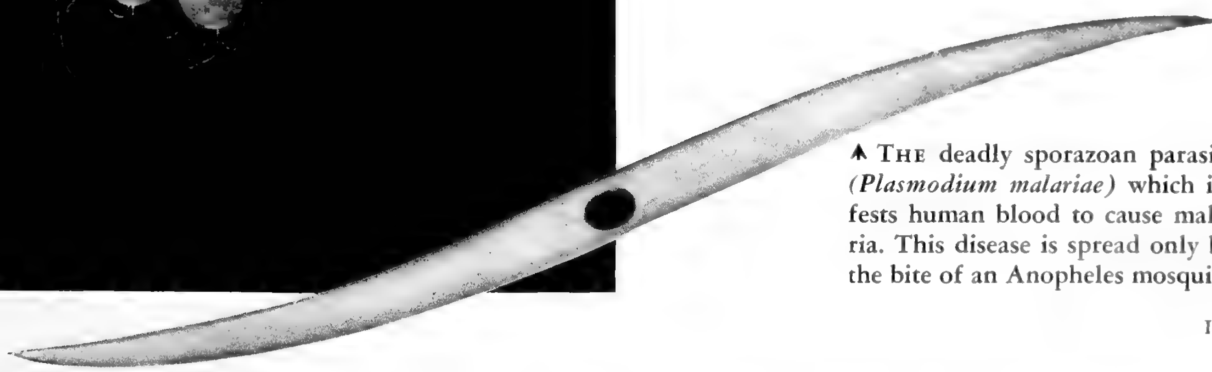
The group Sporozoa contains greatly simplified protozoans, structurally, reproducing by means of spores. They are usually characterized by complicated life histories. Among them are the dreaded organisms that cause malaria and yellow fever, which take an enormous annual toll of human lives. These last diseases are transmitted only by the bite of certain species of mosquitoes, within whose bodies a part of the sporozoans' life history is passed.

These are but a few instances of the protozoan organisms that must be reckoned with. Though they are so minute as to be invisible to the naked eye, because of that very factor, they are all the more dangerous. Mere size is an unimportant matter where vitality is concerned.



◄ A PROTOZOAN COLONY with individuals joining in a spherical cluster: *Synura uvella.* It is sometimes abundant in fresh water reservoirs in early spring. It secretes an essential oil having a fishy flavor, which, though harmless, alarms people when they taste it in their drinking water at such times

► THIS VIRULENT SPECIES *(Trypanosoma gambiense),* during part of its life is parasitic in the human blood, causing the fatal disease known as African sleeping sickness. It is transmitted from one human being to another through the bite of the tsetse fly, within the body of which it passes part of its life history

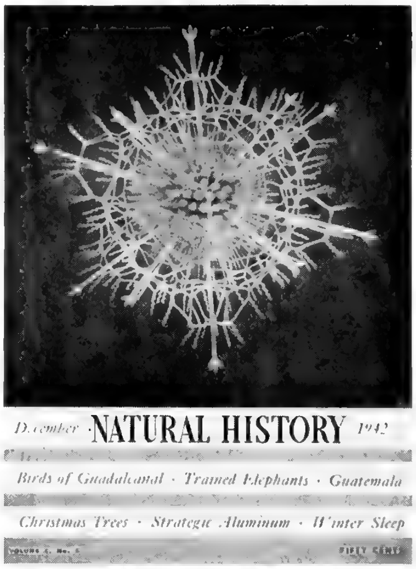


▲ THE deadly sporazoan parasite *(Plasmodium malariae)* which infests human blood to cause malaria. This disease is spread only by the bite of an Anopheles mosquito

THE FRONT COVER

The delicate glass model on the cover of this issue represents the small one-celled animal *Lychnosphaera regina,* greatly enlarged. This tiny protozoan inhabits the surface waters of the Central Pacific. It has a lattice-like glassy skeleton of fragile beauty surrounding the rose-colored clustered lobes of the living animal in the center. Threadlike filaments radiate in all directions to capture still smaller creatures.

The model was created by Herman Mueller, the American Museum's skillful glass blower, under the direction of Dr. Roy Waldo Miner, who, in these pages describes the universe of minute creatures that is revealed by the microscope. Mr. Mueller is shown below assisting Charles H. Coles, the Chief Photographer, in photographing the model in color. The model was rested on a plate glass platform under the carefully adjusted beams of five spotlights. A polarized filter was used to control reflections.



Photograhed by Charles H. Coles

Issued under the direction of the
Committee on Popular Publications
Roy W. Miner, *Chairman*

Birds *and* Man

By FRANK M. CHAPMAN

THE AMERICAN MUSEUM OF NATURAL HISTORY

Issued under the direction

of the

COMMITTEE ON POPULAR PUBLICATIONS

Roy W. Miner, *Chairman*

Background painted by Francis Lee Jaques

BIRDS AND MAN

by

FRANK M. CHAPMAN

A Guide to the Exhibit

Illustrating the Relations between Birds and Man

Shown on the First Floor of the Whitney Wing

GUIDE LEAFLET SERIES, No. 115

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK CITY

ACKNOWLEDGMENTS

In gathering material for and planning the group on which this leaflet is based the author had the cordial support of his colleagues in the Bird Department. With especial pleasure he also acknowledges the indispensable cooperation of William Patten Osborn as artist and exhibitor. Mr. Osborn was assisted by Mr. Charles Tamkin, E. Thomas Gilliard, Paul Richard and others. The birds were mounted by Raymond B. Potter and George Adams. The vegetation was prepared by George E. Petersen of the Department of Preparation. The lettering was done by Margaret Gilliard and Roger O. Siege. The photographs were made by Thane L. Bierwert.

FRANK M. CHAPMAN

SYNOPSIS OF THE EXHIBIT*

* Page numbers in heavy face refer to full page plates illustrating the nine sections of the exhibit.

INTRODUCTORY

There are many parts of the earth occupied by birds where man is unknown; but there is no place inhabited by man where birds are not also found. Their flesh, their feathers, their forms and flight, their habits, their food, their travels, their songs and companionship all may enter into our lives. From the beginning of this association birds have been essentially as they are today but man has risen from the primitive condition, in which some races still remain, to the high stage of civilization his leaders have now reached. We believe that a review of our present and past relations with birds will show that they have played, and continue to play, an inestimably important part in both our mental and physical existence. This review we have attempted to make in the exhibit, "Birds and Man," which this pamphlet has been prepared to accompany.

BIRDS AND MAN

by

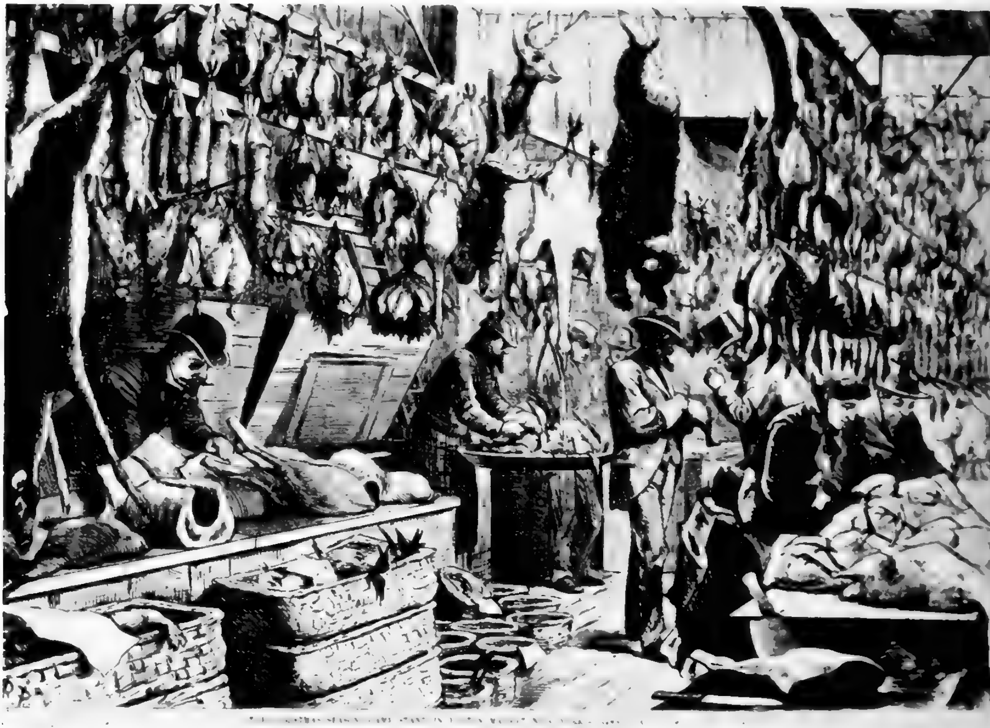
FRANK M. CHAPMAN

SECTION I

BIRDS AS FOOD

. CAPE YORK ESKIMO NETTING DOVEKIES. This is drawn by W. P. Osborn from photo-raphs by Donald B. MacMillan.

The Native Hunter. — Most birds are edible; some of them are exceptionally palatable. It has always been their fate to serve as food. Primitive man is sometimes dependent on them for subsistence. It is probable, for example, that the early Tehuelche could not have lived in Patagonia without the support of the Rhea and its eggs; while the Eskimo could not inhabit Cape York, Greenland, if the Dovekie was removed from his larder. In both these instances, it should be noted, agriculture is impossible or not practiced and the indigenes exist mainly, or wholly, on a fare of flesh. But it is significant to observe that in continental areas, at least, the wants of the native rarely, if ever, caused a serious diminution in the numbers of birds. Should this fall below the point of support or profitable pursuit, change in the pursuer's food or habitat automatically gives his prey an opportunity to regain its status.



II. THE CHRISTMAS SEASON—GAME STAND IN FULTON MARKET, NEW YORK. Drawn by A. B. Frost. (A print from Harpers Weekly, 1878.)

The Market Hunter. – With the increase in population following the white man's appearance and improvement in transportation which made trade-centers accessible, the Market Hunter arose and his efforts to supply the demand for edible birds mark one of the most destructive periods of our relation with birds. In North America, Wild Pigeons, exceptionally vulnerable because of their communal habits, in spite of their incredible abundance, were among the first to disappear. Other species, which could be killed by wholesale, were on their way to follow them. Our markets were glutted with game birds as our copies of contemporary prints demonstrate. Obviously we were recklessly squandering an invaluable asset that could never be replaced.

For example:

In 1864, one shipment of Prairie Hens weighed 20 tons. (D. G. Elliot.)

In 1861, 14,850,000 wild Passenger Pigeons were shipped from the Petoskey, Mich., "nesting."

In 1909, 5,719,214 game birds were sold in the markets of New Orleans.

Fortunately, the danger was seen by true sportsmen who, as the first step in reform, secured the passage of laws prohibiting the sale of birds for food. This ended the day of the Market Hunter.

Hunting for Sport. — The Market Hunter was succeeded by the Hunter for Sport. He gratified his inherent love of the chase but created and obeyed the laws shortening the open season, limiting the size of the daily bag, and aiming to restrict the annual kill to not more than the annual increase. He advocated enlargement of suitable habitat with additions to the food supply; in short, spared no effort to augment the parent stock. Of recent years the lives of an increasing number of sportsmen give an encouraging forecast of a change of heart among their kind. As they become older, interest in the living bird replaces the desire to capture it, and the inborn love of the chase finds an outlet in bird photography. It requires more skill to secure a satisfactory picture of a bird than to shoot it, and the trophy obtained is proof of one's patience and ingenuity often of value to science and sometimes to art. Compare the brace of dead Quail bagged by the sportsman with the camera hunter's unique photograph of a colony of nesting Flamingoes and this point becomes clear.

Falconry. — Asia is the home of Falconry. It appears to have been known in China some 2000 B.C. It was practiced in Japan in 600 B.C. and at an equally early period in India, Arabia, Persia and Syria. It was a sport of Ancient Egypt and other parts of northern Africa and was mentioned by Aristotle. It was introduced into England from the Continent about 860 A.D. and was that country's leading sport up to the middle of the 17th Century.

With the increasing use of firearms in hunting, Falconry declined but it is still followed throughout the world, chiefly in Asia. Of recent years a growing interest has been shown in Falconry in America. It is a true sport and the performance of the Falcon and the paraphernalia employed are of greater importance than the quarry pursued.

Falconry has a literature of its own with volumes devoted to its various phases. For a general review of its history and methods read the article in the Encyclopaedia Britannica.

References

1871. Musters, George Chaworth. At Home with the Patagonians. London. Murray.

1914. Hornaday, William T. Wild Life Conservation in Theory and Practice. With a chapter on Private Game Preserves by Frederic C. Walcott. Yale University Press.

1925. Macmillan, Donald B. Four Years in the White North. Boston: The Medici Society of America.

1933. Gross, A. O. History and Progress of Bird Photography in America. Fifty Years Progress of American Ornithology. American Ornithologists' Union.

Section I

BIRDS AS FOOD

(See opposite page)

Patagonia Tehuelches pursuing Rhea with bolas. Partly drawn by W. P. Osborn from a photograph of gauchos by Martin Munkacsi.

A Rhea's egg is also shown.

Cape York, Greenland Eskimo netting Dovekies. Drawn by W. P. Osborn from photographs by Donald B. Macmillan.

Dovekie is also shown.

Display of Dakota game birds by Market Hunters about 1875. A contemporary print.

Game in a New York City market. A print from Harpers Weekly, 1878.

The Quail Hunter. Drawn by W. P. Osborn,
and (below) his bag.

The Camera Hunter and (below) his "bag" of Flamingoes. By F. M. Chapman.

Peregrine Falcon or Duck Hawk Hooded for Hunting.

BIRDS AND MAN
MAN HAS ALWAYS BEEN ASSOCIATED
TH BIRDS. HIS DEVELOPMENT, FROM
VAGERY TO CIVILIZATION, HAS BEEN
ACCOMPANIED BY AN INCREASING REALIZATION OF THEIR POWER TO ADD TO HIS WELL-BEING. AT FIRST KILLED FOR FOOD
THEY ARE NOW PROTECTED AS FRIENDS. THIS ALCOVE PRESENTS AN OUTLINE OF THIS CHANGE IN THEIR RELATIONS.
SYNOPSIS
CTION I BIRDS AS FOOD
THE NATIVE HUNTER
THE MARKET HUNTER
HUNTING FOR SPORT
CTION II BIRDS AS CLOTHING AND IN ADORNMENT
BIRDS AS OMENS AND SYMBOLS; IN MYTHOLOGY AND TRADITION
CTION III BIRDS AS EMBLEMS AND INSIGNIA
BIRDS AS HIEROGLYPHS
SECTION IV BIRDS IN BOOKS
LITERATURE
HISTORY
SCIENCE
SECTION V BIRDS IN ART
SECTION VI ECONOMIC ORNITHOLOGY I
THE FOOD OF BIRDS
SECTION VII ECONOMIC ORNITHOLOGY II
DOMESTICATION
SECTION VIII ECONOMIC ORNITHOLOGY III
INTRODUCTION OF BIRDS
THE FEATHER TRADE
GUANO
BIRDS AS PETS
SECTION IX THE SENTIMENT OF BIRDS
BIRD SONG
BIRDS AS FRIENDS
BIRD SANCTUARIES
BIRDS AS FOOD
THE NATIVE HUNTER
THE MARKET HUNTER
WITH INCREASE IN POPULATION AND CIVILIZATION THE DEMANDS OF MEN FOR BIRDS AS FOOD BECAME LARGER, THE PROFESSIONAL HUNTER AROSE, IMPROVED TRANSPORTATION CREATED NEW MARKETS AND THE DEMAND WAS UNLIMITED. THE RESULT WAS GREAT DECREASE OR EXTINCTION OF THE BIRDS CONCERNED.
THEREFORE, TO PRESERVE BIRDS FROM EXTERMINATION THEIR SALE AS FOOD HAS BEEN PROHIBITED BY LAW.
HUNTING FOR SPORT
IN THIS COUNTRY MARKET-HUNTING HAS BEEN ELIMINATED, BUT HUNTING FOR SPORT REMAINS.

SECTION II

BIRDS AS CLOTHING AND IN ADORNMENT

Fur, rather than feathers, has clothed man. The innumerable instances in which the skins of mammals tanned, as in buckskin, or natural, as in a guanaco pelt, are pertinent illustrations. But the down-lined skins of diving-birds, like the Murre and Dovekie, make warm soft garments and are widely employed by the natives of northern latitudes. Note the Eskimo's hooded shirt of Murre's skins in our exhibit.

Woven feather-garments may also be used but in by far the greater number of cases feathers are worn for meaningless display or as insignia rather than as clothing. I except here the wearing by civilized man, or rather woman, of ostrich boas, swans-down cloaks and similar semi-display apparel as more properly to be considered under the Feather Trade rather than with the use of feathers by indigenes. In considering the employment of feathers for adornment it is difficult to draw the line between casual, meaningless display and actual significance. The necklace of South American parrots' feathers shown was probably only an expression of its wearer's sense of beauty; but it may have indicated rank or profession.

Doubtless feathers only gradually acquired a significance that restricted their use to the man. It was not until symbolism gave way to fashion that feathers were widely worn by woman. Here again we leave primeval, for modern conditions, to be treated as an outcome of the Feather Trade, not as a custom of the indigenes.

BIRDS AS OMENS AND SYMBOLS: IN MYTHOLOGY AND IN TRADITION

The remainder of this, and all the next section, belong primarily in the province of ethnology. Nevertheless birds supply so many of the facts on which the superstitions, beliefs and actions of man are founded that the ornithologist may at least be permitted to name the characteristics that, in his opinion, have exerted the widest and most pronounced influence. Possibly first among them, is the voice of birds, particularly of birds possessing loud, striking notes. The *hoot* of an Owl may reach a hundred or more pairs of ears while the bird remains unseen. So deep and lasting has been the significance attached to Owls' notes, and other ominous bird-calls, that belief in their effectiveness enters into our current superstitions. Doubtless the chief reason for

Owls' invisibility is their nocturnal habits. Their weird cries gain in impressiveness from the mystery of the night.

Following the calls of birds in their power over the untrained mind, we place flight with its marvelous mobility; migration, and its accompanying inexplicable appearances and disappearances; plumage and its varied uses; human-like habits that reflect the customs of men; all have played their parts in the life of primitive man. The depth of his belief in the significance of the traits of birds may be measured by the degree of his ignorance. With the mental development that accompanied increasing knowledge, ritual and augury followed superstition and they faded, in time, to the fable, legend and tradition of today.

Aristophanes was inspired by more than a "Comedy" when he wrote (Frere's translation):

> "For every oracular temple and shrine,
> The birds are a substitute equal and fair
> For on us you depend and to us you repair
> For counsel and aid when a marriage is made,
> A purchase, a bargain, a venture in trade.
> Unlucky or lucky, whatever has struck ye,
> An ox or an ass that may happen to pass,
> A voice in the street, or a slave you may meet,
> A name or a word, by chance overheard,
> If you deem it an omen, you call it a Bird,
> And if birds are your omens, it clearly will follow
> That birds are a proper prophetic Apollo."

The 2300 years, more or less, that have passed since the time of Aristophanes have not removed birds from our fables and folk-lore. We may not interpret literally the significance of an Owl's call at our door, but we wish that the bird had chosen some other person's door! The cry of the Cuckoo, or "Rain-Crow," may not actually arouse our faith in an approaching storm but, at least, it may increase the chances of a shower. And when we speak of the stork as the bearer of babies, or a "Little Bird" as our source of information, we are perpetuating pleasant custom. Countless similar instances of inherited tradition might be cited. Doubtless the reader will recall some of his own.

Section III

BIRDS AS EMBLEMS AND INSIGNIA

Entering Section III of our exhibit we find more definite relations between birds and man than those described in the latter part of the preceding section. Feathers have now acquired recognized meanings and specified uses.

Section II

BIRDS AS CLOTHING AND ADORNMENT

(See opposite page)

An Eskimo hooded cape of Murre's skins.

A South American necklace of Parrots' feathers.

BIRDS AS OMENS AND SYMBOLS

Barn Owl.

Jove.

European Cuckoo.

Minerva.

Pegasus.

European Kingfisher.

The Stork races the Doctor.

The Winged Sun.

Totem capped by Raven.

Totem capped by Raven.

Raven a bird of ill-omen.


BIRDS AS CLOTHING AND IN ADORNMENT
CLOTHING
ADORNMENT
THREATENING THE EXISTENCE OF THE BIRDS THAT BORE THEM. PARADISE BIRDS MIGHT INDEFINITELY SUPPLY PLUMES FOR THE NATIVES OF NEW GUINEA BUT THEY COULD NOT MEET THE MARKET
MILLINERS. IT WAS NOT UNTIL AIGRETTES BECAME FASHIONABLE THAT THE HERONS FROM WHICH THEY WERE TAKEN BECAME RARE.
BIRDS AS OMENS AND SYMBOLS; IN MYTHOLOGY AND TRADITION
TO THE BIRDS' POWER OF FLIGHT, THEIR MYSTERIOUS COMINGS AND GOINGS, THEIR VOICE, VARIED PLUMAGE, AND HUMAN-LIKE CHARACTERISTICS, WE MAY ATTRIBUTE THE INFLUENCE THEY HAVE EXERTED ON THE MIND AND CUSTOMS OF PRIMITIVE AND EVEN MODERN MAN. THIS IS SHOWN IN THE USE OF BIRDS AND FEATHERS AS SYMBOLS AND EMBLEMS IN COUNTLESS MYTHS AND LEGENDS, IN RITES, CEREMONIES AND AUGURIES, AND EVEN IN CURRENT SUPERSTITIONS, IN FABLE AND FOLK-LORE.
OMENS
UMAN-FACED, NOCTURNAL, WEIRD-VOICED
MYSTERY, OWLS APPEALED STRONGLY TO
INATION OF EARLY MAN. TO THIS DAY
CONSIDERED BIRDS OF ILL OMEN. THE
PLUMAGE AND RAUCOUS CROAK OF
AVE CAUSED COUNTLESS SUPERSTITIONS.
KOOS' LOUD NOTES ARE VARIOUSLY INTER
FABLE AND FOLK-LORE, AND WHERE THE
KNOWN AS 'RAIN-CROWS' THEY SERVE THE
THE LOCAL PROPHETS WHO BASE THEIR
S, SOMETIMES WITH REASON, ON THE
OF BIRDS.
MYTHOLOGY
IN MYTHOLOGY CERTAIN BIRDS WERE ASSOCIATED WITH THE GOD OR GODDESS WHOM IN CHARACTER OR APPEARANCE THEY WERE BELIEVED TO TYPIFY. THUS IT WAS THE POWER OF THE EAGLE THAT MADE IT THE BIRD OF JOVE; THE BEAUTY OF THE PEACOCK THAT CONNECTED IT WITH JUNO; THE ALLEGED WISDOM OF THE OWL THAT MADE IT THE BIRD OF MINERVA.
SYMBOLS
EGYPTIAN WINGED SUN
WINGS, AS BIRDS' MOST DISTINCTIVE CHARACTER AND AS INDICATIVE OF THEIR MASTERY OF THE AIR, ARE WIDELY USED AS SYMBOLS. THEY ARE GIVEN TO MERCURY AND PEGASUS AS WELL AS TO ANGELS AND EVEN TO THE WIND, AND THE DAY MAY BE BORNE ON THE WINGS OF THE MORNING.
THE ALLEGED HEAD-HIDING OSTRICH IS SYMBOLIC OF SELF-DECEPTION; THE GOOSE OF STUPIDITY; THE GAME-COCK OF AGGRESSIVENESS; THE PEACOCK OF PRIDE; AND HALCYON, THE EUROPEAN KINGFISHER, IS SYMBOLIC OF CALM WEATHER.
CURRENT FOLK-LORE; TRADITION
THE DEPTH OF PRIMITIVE MAN'S BELIEF IN THE SIGNIFICANCE OF THE WAYS OF BIRDS IS MEASURED BY THE DEGREE OF HIS IGNORANCE. WITH INCREASING KNOWLEDGE RITUAL WAS FORGOTTEN, UNQUESTIONED OMENS FADED TO SUPERSTITIONS. THESE, IN TURN, BECAME FABLE AND LEGEND AND EVENTUALLY THE INHERITED HABIT OR TRADITION OF TODAY.
THUS WHEN A MAN GRAVELY TIPS HIS HAT TO A MAGPIE, HE FOLLOWS ANCESTRAL CUSTOM; WHEN WE SPEAK OF STORKS AS BEARERS OF BABIES, OR OF 'LITTLE BIRDS' AS BEARERS OF INFORMATION, WE ARE GOVERNED BY TRADITION.

The majestic appearance and predatory habits of Eagles have everywhere made them the emblems of war, and Eagles' plumes are no longer merely feathers, but are worn by the warrior as indicating his "calling" or as evidence of his achievements.

More specifically, feathers give wings to the arrow, messenger of war, and feathers also provide the pen of peace, though it may also be used to promote far from peaceful purposes.

As insignia of profession or rank, feathers are used throughout the world. The Black Cock's quill of the Swiss guide plays a minor rôle but is no less significant than the Peacock's plumes of the Far East potentate. It is singular that in Hawaii, where birds are small and few in species, the most elaborate native feather-work in the world should have been perfected. Only a limited number of the woven feather cloaks worn by Hawaiian nobility are now in existence. They are valued at $10,000 or more.

Incidentally, it is a tribute to the widespread influence of birds that man should have selected characteristic species to be figured on the stamps and coinage of his country. But when the philatelist refers the Dove and the Dovekie to the same bird family he obviously is in need of the services of an ornithologist!

As birds made deeper and more varied impressions on the mind of man they played a more important part in his life. The imitation of birds' calls may have become words in our spoken language, but it is certain that the birds themselves have helped to form a written language. Serving at first as pictographs or ideographs, they later became hieroglyphs and were consistently used as low reliefs on slabs or murals, on papyrus scroll, in codex as interpretable records of contemporary history.

Moreau, who writes with the authority of an ornithologist on the ground, states that 12 named and 4 unnamed species of birds appear in Egyptian hieroglyphs; while Tozzer and Allen, speaking of the three Mayan codices still in existence, write: "These remains of a once extensive literature show evidence not only of considerable intellectual attainments on the part of their authors but also a high degree of artistic skill in the drawings and hieroglyphics" (p. 283). Here is a subject that might be pursued through the beginnings of all languages.

References

1910. Tozzer, A. M., and Allen, G. M. Animal Figures in the Maya Codices. Peabody Mus. Amer. Arch. and Ethn. IV, 3, pp. 283-372.

1923. Ingersoll, Ernest. Birds in Legend Fable and Folklore. Longman, Green & Co.

1930. Moreau, R. E. The Birds of Ancient Egypt. (Meinertzhagen, Richard E., "Nicoll's Birds of Egypt," Chapter III, pp. 58-77).

III. EGYPTIAN FUNERARY STELA. Funerary Stela of Nesi-Khonsu showing bird hieroglyphs painted on limestone. Loaned by Metropolitan Museum of Art from its collections excavated at Deir El Bahri, Thebes, XXVI Dynasty (663-525 B.C.).

Section III

BIRDS AS EMBLEMS AND INSIGNIA

(See opposite page)

Indian War Bonnet of Eagle feathers.

The Dove of peace.

Feathered Arrow.
Quill Pen.

Kiowa Eagle dance.

Hawaiian Chieftain's feather cloak and the bird that supplies the feathers.

Alaskan ceremonial mask.

A Medicine Man's plume.

Mayan bird hieroglyphs.

Native birds as Emblems on stamps and coins.

Egyptian bird and other glyphs. Egyptian funerary stela of Nesi-Khonsu showing bird hieroglyphs painted on limestone. Loaned by Metropolitan Museum of Art from its collections excavated at Deir El Bahri, Thebes, XXVI Dynasty (663-525 B.C.)


BIRDS AS EMBLEMS AND INSIGNIA
EMBLEMS OF WAR AND PEACE
EMBLEMS OF RANK AND OF
BIRDS AS HIEROGLYPHS
BIRDS ON STAMPS AND COINS

Section IV

BIRDS IN BOOKS

Literature. – In considering Birds in Books we accord first place chronologically and historically to the birds of the bible. There is a surprising amount of bird-lore in the bible, chiefly in the Old Testament. About 25 of the larger species are mentioned by name. Smaller ones are referred to under group terms.

Primarily there is a division (Leviticus) into "clean" (= edible) and "unclean" (= inedible) groups in which existing standards are more or less closely followed. The Mosaic law of bird protection, however, contains provisions which to us seem inconsistent. It reads:

"If a bird's nest chance to be before thee in the way in any tree, or on the ground, whether they be young ones, or eggs, and the dam sitting upon the young, or upon the eggs, thou shalt not take the dam with the young:

"But thou shalt in any wise let the dam go, and take the young to thee; that it may be well with thee, and that thou mayest prolong thy days." (Deut. XXII, 6 and 7).

Nesting, migration and song are alluded to usually metaphorically or poetically. Thus Jeremiah (VIII; 7) wrote: "Yea, the stork in the heaven knoweth her appointed times; and the turtle [dove] and the crane and the swallow observe the time of their coming," and Solomon (Song, II, 12) writing, "the time of the singing of birds is come," is a poet and herald of spring.

Thus from the beginnings of literature the sensitive mind of the poet has responded to the influence of birds. It was apparently a popular interest in birds that induced Aristophanes (B.C. 448-385) to use them as the subjects of his comedy, "Birds"; and later, poets "Singing hymns unbidden 'Til the world was wrought to sympathy with hopes and fears it headed not" have most eloquently expressed the emotions birds arouse within us. We have only to recall the works of Chaucer, Shakespeare, Shelley, Wordsworth, Coleridge, Burns and Keats in England, and in America, Bryant, Emerson, Longfellow, Lowell and Whitman to realize how birds have inspired the poets.

Writing some 300 years ago, how well Izaak Walton expressed man's varied debts to birds and, with the prescience of the poet, predicted their future relations. "The very birds of the air," he said, "those that be not hawks, are both so many and so useful and pleasant to mankind that I must not let them pass without some observations. They both feed and refresh him – feed him with their choice bodies and refresh him with their heavenly voices"· a point of view more appreciative than consistent.

IV. BIRDS PLAYING A PART IN HISTORY. October 7, 1492, Columbus changed his course to follow land birds, thus shortening his route by 200 miles.

The prose of bird literature is devoted largely to descriptions of bird-life and to experiences with birds in nature. Much of it is to be classed with the science or biography of ornithology. But in America we have as contributors to the prose literature of birds Thoreau, Torrey, Burroughs and many others. Certainly none among them has responded more deeply to the bird in its haunts than Burroughs writing in Wake Robin: "Mounting toward the upland again, I pause reverently as the hush and stillness of twilight come upon the woods. It is the sweetest, ripest hour of day, and as the Hermit's evening hymn goes up from the deep solitude below me, I experience that serene exaltation of

sentiment of which music, literature, and religion are but the faint types and symbols".

History. — It is interesting that the birds of history should so often be recorded as saving man from disaster — starvation, conquest, and the perils of the sea. It was migratory Quail that came to the rescue of the Children of Israel, cackling Geese that saved Rome; southbound migrants that guided Columbus when his discouraged crew was on the verge of mutiny. The event doubtless influenced the history of our continent and is of sufficient interest and importance to be briefly recorded here. On October 7, 1492, Columbus was 720 miles northeast of the Bahamas, when numerous small land-birds, flying southwest, crossed his route. They were the most promising evidences of land that he had encountered, and he altered his course to follow them, thereby shortening his voyage 200 miles and landing in San Salvador, Bahamas, instead of Florida.

Science. — Birds are such many-sided exponents of their environment; they are so abundant and so easily observed that they have induced man not alone to establish a literature and a history of ornithology but to create also a science of birds for the reception of what he learns concerning their structure, relationships, and habits.

Aristotle (B.C. 385-322) is the first ornithologist of record. But birds occupied too important a place in the art and life of the Egyptians not to have also figured in their literature. Indeed, we need go no further back than Aristophanes to find apparent common knowledge of at least our everyday birds. Whether or not Aristotle had predecessors, for the following nearly 2000 years he had no comparable successors. So far was he in advance of his time that, as Warde Fowler remarks, naturalists were content to follow him alike when he was right and when he was wrong. The bibliographer is referred to Alfred Newton's scholarly review of the history of bird literature (Dictionary of Birds, 1896). I mention, therefore, the names of only such outstanding contributors to ornithology during this period as Willoughby and Ray (1676), Edwards (1743), Buffon (1749), Linnaeus (1758) and Brisson (1760).

Provided now with a classification and nomenclature, we may leave the avifauna of the Old World to pass to that of the New.

At about this time Mark Catesby (1731-1743) was producing in London his two great folios on the *Natural History of Carolina*, a work which, after 200 years, is still a notable publication. It was followed by Pennant's *Arctic Zoology* (1784-1787), but the earliest attempt to treat of all the birds of the North America of that day was that of Alexander Wilson (1808-1814), the Scotch poet and weaver, since well-called the Father of American Ornithology.

Wilson's pioneer work laid the foundation for Audubon's incomparable *Birds of America* (1827-1839). Combining in one man the artist, explorer, field student, writer and publisher, Audubon's achievements will always command the world's unstinted admiration. His influence on the growth of bird study was profound. Works on American birds by Baird, Cassin, Coues, Ridgway and others now brought the possibilities of bird study within the reach of everyone. All parts of our country had their bird students and in 1883 they founded the American Ornithologists' Union, which, since its organization, has published *The Auk*, an authoritative quarterly (address, American Museum of Natural History).

From the A.O.U. grew the first Audubon Society (1886) and the Bureau of Economic Mammalogy and Ornithology (now included in the Fish and Wildlife Service). And in these two educational and research institutions we have the roots of the popular and technical phases of the bird study and conservation. The visitor is referred to other parts of this hall for exhibits illustrating the ornithology of today.

At the bottom of this section copies of three different standard works on ornithology are shown: Roberts' *Birds of Minnesota*, Coues' *Key to North American Birds*, and Murphy's *Oceanic Birds of South America*.

SOME BOOKS ON EASTERN NORTH AMERICAN BIRDS

With any of these works the student has made a beginning. But let him visit the Museum's library (5th floor) before making a choice.

*1808-1814. Wilson, A. American Ornithology. Many Editions.
*1831-1839. Audubon, J. J. The Birds of America. Plates, 4 vols. text.
1872. Coues, E. Key to N. A. Birds. Later editions; Last, 1903.
1886. Am. Orn. Union Check List of N. A. Birds. Rev. Editions, 1910, 1931.
1874-1895. Bendire, C. E. Life Histories N. A. Birds. 2 vols.
*1895-1932. Chapman, F. M. Handbook of Birds of Eastern North America.
1901-1942. Ridgway, R., Friedmann, H. Birds of North and Middle America. 9 parts.
*1910. Eaton, E. H. Birds of New York. 2 vols.
1918-1942. Cory, C. B., Hellmayr, C. E., Conover, B., Catalogue of Birds of the Americas. 11 parts.
1919-19—. Bent, A. C. Life Histories N. A. Birds. 14 parts.
*1925-1929. Forbush, E. H. Birds of Mass. and other N. E. States. 3 vols.
*1932. Howell, A. H. Birds of Florida.
*1932. Roberts, T. S. Birds of Minnesota. 2 vols.
*1934. Taverner, P. A. Birds of Canada.
*1937. Stone, W. Bird Studies at Old Cape May. 2 vols.
*1939. Peterson, R. T. A Field Guide to the Birds.
*1940. Todd, W. E. C. Birds of Western Pennsylvania.
1942. Cruickshank, A. L. Birds Around New York City.
*1942. Pearson, T. G., Brimley, C. S. and H. H. Birds of North Carolina.

* Colored illustrations.

Skylark.

Bobolink.

Section IV

BIRDS IN BOOKS

(See opposite page)

Nightingale.

Hermit Thrush.

Columbus' vessel the "Santa Maria."

Aristotle.

Linnaeus.

Alexander Wilson.

John James Audubon

Annual Meeting of the American Ornithologists' Union, Washington, D. C. Nov. 1892.

Roberts' "The Birds of Minnesota."

Murphy's "Oceanic Birds of South America."

Coues' "Key to North American Birds."

LITERATURE

FIRST ON OUR LIST OF BOOKS REFERRING TO BIRDS IS THE BIBLE. BIBLICAL REFERENCES TO BIRDS ARE FOUND CHIEFLY IN THE OLD TESTAMENT. ABOUT 25 LARGER SPECIES ARE MENTIONED BY NAME. SMALLER ONES BY GROUP TERMS. THE DOMESTIC FOWL IS REFERRED TO IN THE NEW, BUT NOT IN THE OLD TESTAMENT. ASIDE FROM A DIVISION INTO 'CLEAN' (EDIBLE) AND 'UNCLEAN' (INEDIBLE) GROUPS, WHICH CLOSELY FOLLOWS EXISTING STANDARDS, AND THE MOSAIC LAW OF PARTIAL BIRD PROTECTION, BIRDS ARE USUALLY REFERRED TO IN THE BIBLE METAPHORICALLY OR POETICALLY. SOLOMON (SONGS, II) WHO SANG "THE TIME OF THE SINGING OF THE BIRDS IS COME" IS A POET AND HERALD OF SPRING RATHER THAN A RECORDER OF MIGRATION. THUS FROM THE BEGINNINGS OF LITERATURE THE SENSITIVE MIND OF THE POET HAS RESPONDED TO THE INFLUENCE OF BIRDS.

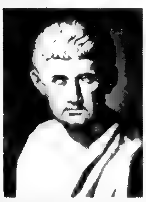
IT WAS APPARENTLY A POPULAR INTEREST IN BIRDS THAT INDUCED ARISTOPHANES (448-385 B.C.) TO USE THEM AS THE SUBJECTS OF A COMEDY, AND ENGLISH POETS OF A LATER PERIOD SEEM TO HAVE BEEN EVEN MORE DEEPLY MOVED BY THE CHARM AND SIGNIFICANCE OF BIRD-LIFE. RECALL THE WORKS OF CHAUCER, SHAKESPEARE, COLERIDGE, WORDSWORTH, KEATS, SHELLEY, AND BURNS.

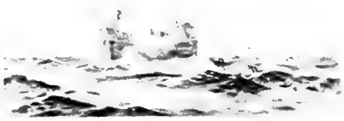
THE PROSE OF BIRD LITERATURE RELATES CHIEFLY TO BIRDS' HABITS AND IS USUALLY CLASSED WITH BIRD BIOGRAPHIES OR ORNITHOLOGY. BUT TO MEN LIKE BURROUGHS, HUDSON AND MANY OTHERS, THE BIRD IS AN INSPIRATION RATHER THAN A SPECIMEN AND WHAT THEY WRITE IS LITERATURE RATHER THAN SCIENCE.

HISTORY

HISTORY CONTAINS RECORDS OF INCIDENTS AND EVENTS IN WHICH BIRDS HAVE PLAYED A PART IN SHAPING THE COURSE OF HUMAN AFFAIRS. THUS IN 338 B.C. THE SACRED GEESE THAT GAVE THE ALARM WHICH SAVED ROME MAY BE ACCORDED A PLACE IN HISTORY; WHILE THE MIGRANT BIRDS THAT DIRECTED THE COURSE OF COLUMBUS MAY HAVE INFLUENCED THE DEVELOPMENT OF A CONTINENT.

ON OCTOBER 7, 1492, COLUMBUS WAS 720 MI[LES] EAST OF FLORIDA AND 505 MILES NORTHEAST OF [THE] BAHAMAS. HIS DISCOURAGED MEN WERE ON THE VE[RGE] OF MUTINY WHEN NUMEROUS SMALL LAND-BIRDS, F[LY]ING SOUTHWEST, CROSSED HIS ROUTE. HE ALTERED [HIS] COURSE TO FOLLOW THEM, THEREBY SHORTENING [HIS] VOYAGE 200 MILES AND LANDED AT SAN SALVADO[R,] BAHAMAS, INSTEAD OF FLORIDA.





SCIENCE

ARISTOTLE (385-322 B.C.) IS THE FIRST ORNITHOLOGIST OF RECORD. DOUBTLESS HE HAD PREDECESSORS, BUT FOR THE FOLLOWING NEARLY 2000 YEARS HE HAD NO COMPARABLE SUCCESSORS. THE OUTSTANDING ORNITHOLOGICAL LANDMARKS DURING THIS PERIOD WERE THE WORKS OF WILLUGHBY AND RAY (1676), EDWARDS (1743), BUFFON (1749), LINNAEUS (1758), BRISSON (1760).

IN AMERICA, CATESBY'S 'NATURAL HISTORY OF SOUTH CAROLINA' (1731-1743) WAS THE FIRST MAJOR WORK ON BIRDS. IT WAS FOLLOWED BY PENNANT'S 'ARCTIC ZOOLOGY' (1784-1787) BUT THE EARLIEST ATTEMPT AT A COMPLETE NORTH AMERICAN ORNITHOLOGY WAS THAT OF ALEXANDER WILSON (1808-1814), SINCE CALLED "FATHER OF AMERICAN ORNITHOLOGY." WILSON'S WORK LAID THE FOUNDATION FOR AUDUBON'S INCOMPARABLE 'BIRDS OF AMERICA' (1827-1839) WHICH EXERTED AN IMMEASURABLE INFLUENCE ON THE STUDY OF BIRDS. BIRD STUDENTS AND WORKS ON AMERICAN BIRDS B[Y] BAIRD, CASSIN, COUES, RIDGWAY AND OTHE[RS] HAVE STEADILY INCREASED IN NUMBERS, LEADING IN 1884, TO THE FOUNDING OF THE AMERICAN ORNITH[OL]OGISTS' UNION. THIS ORGANIZATION GAVE BIRT[H] TO THE AUDUBON SOCIETY AND STILL WIDELY PROMOTE[S] THE STUDY AND CONSERVATION OF BIRDS.

ANNUAL CONGRESS OF THE AMERICAN ORNITHOLOGISTS' UNION
WASHINGTON, D.C., NOV 1892

V. GANNETS. Modeled by Thomas Famiglietti.

SECTION V

BIRDS IN ART

In addition to their manifold claims on the artist, the designer and decorator, birds doubtless receive more attention from the illustrator than any other forms of wild life. Such illustrations may rank high as art, nevertheless they are made primarily to accompany text in either book or portfolio. The author, therefore, both popular or scientific, is an effective promoter of bird art.

It is the crude outlines of birds in the caves of France and Spain that are our oldest records of man's contact with birds. They were made, it is said, about 15,000 years ago.

Compare them with our next exhibit, the geese of Medum, Egypt. Here, as far as art is concerned, we have the difference between savagery and civilization. In time, if our chronology is approximately correct, the cave drawings are 12,000 years the older.

Whether the creator of the goose mural was an Audubon or a Fuertes of his time, or whether he merely represented the average bird painter, is unknown. But certain it is that his work is comparable with that of the best bird muralists of our own day.

Our specimens of the work of America's two greatest bird artists show them as illustrators; Audubon, by a slightly reduced reproduction of the Carolina Paroquet plate in his *Birds of North America;* Fuertes, by the original water-color of European Starlings, made by him to serve as the frontispiece of the latest (1903) edition of Coues' *Key*. It is shown as printed in a copy of this work at the bottom of the preceding section. The discriminating critic will, we believe, find the character of each artist reflected in his work.

The paintings of the great Swedish bird artist, Liljefors, were pure art untrammelled by the needs or restrictions of science. Our example is from *Ute I Markerna.* Frank W. Benson has presented us with an etching in a field he has made his own, and we conclude this brief exhibit with a drawing characteristic of the Japanese school.

Lovers of bird art will find exhibits of the work of Louis Fuertes and of Joseph Wolf in the gallery of bird paintings on the 4th floor, Whitney Wing.

Sculptors have not drawn widely on birds as subjects and we are therefore privileged to demonstrate the possibilities in this field by the "Gannets" of Thomas Famiglietti, formerly of the Museum staff.

References

1933. Sutton, G. M. Fifty Years of Progress in American Bird-Art. (Fifty Years Progress in American Ornithology, Amer. Orn. Union.)

1942. Peterson, Roger T. Bird Painting in America. Audubon Magazine, Vol. XLIV, No. 3, May-June, pp. 166-176.

Section VI

ECONOMIC ORNITHOLOGY I

THE FOOD OF BIRDS

Economic Ornithology treats of the ways in which birds affect the food-supply, health and financial resources of man. These ways are so numerous, so varied, and so contradictory that the status of any bird can be determined only by a study of its habits throughout its range and at all seasons.

Man, the agriculturist, exhibits so great an influence on his environment that wherever he exercises his potentialities he creates a world of his own. His relations to birds, therefore, should always be viewed in the light of conditions for which he himself is largely responsible.

Section V

BIRDS IN ART

(See opposite page)

Drawings of Caveman.

Drawings of Caveman.

These outlines are from Salomon Reinach's "Repertoire de l'Art Quarternaire" (1913).

The Geese of Medum, Egypt, 3000 B.C. White-fronted, Bean and Red-breasted Geese. The original is in the Museum at Cairo. A facsimile is in the Metropolitan Museum of Art, N. Y.

Carolina Paroquets.
Reduced from Audubon.

European Starlings.
Fuertes' frontispiece for Coues' "Key" (See Section IV).

Swans.
By Bruno Lijefors. From his "Ute I Markerna."

Mallards.
Etching by Frank W. Benson.
Presented by Artist.

Goshawk.

Japanese Print.

Gannets.
Thomas Famiglietti.


BIRDS IN ART
THE FIRST KNOWN BIRD DRAWINGS ARE THE CRUDE OUTLINES MADE ABOUT 15,000 B.C. BY THE CAVEMEN OF SOUTHERN FRANCE AND NORTHERN SPAIN ON THE WALLS OF THEIR DWELLINGS. BY 3000 B.C. BIRD ART HAD REACHED A DEGREE OF PERFECTION SHOWN BY THE BEAUTIFUL MURAL OF THE MEDUM GEESE AND OTHER EARLY EGYPTIAN PAINTINGS. THIS STAGE OF DEVELOPMENT WAS NOT AGAIN APPROACHED UNTIL THE TIME OF AUDUBON, 4600 YEARS LATER.
BIRD ART HAS FOUND ITS WIDEST OPPORTUNITY FOR EXPRESSION IN ILLUSTRATING WORKS ON ORNITHOLOGY. SUCH ILLUSTRATIONS MAY VARY FROM A PEN-AND-INK OUTLINE TO PAINTINGS BY AN AUDUBON OR A FUERTES. IN ANY CASE ACCURACY IS ESSENTIAL.
ASIDE FROM FROM FILLING THE NEEDS OF SCIENCE, BIRDS' BEAUTY, GRACE OF FORM AND MOTION MAKE THEIR OWN APPEAL TO THE PAINTER AND SCULPTOR.
IN COUNTLESS WAYS BIRDS ALSO SERVE THE DESIGNER AND DECORATOR WHOSE SKILLFUL EMPLOYMENT OF HERON AND CRANE MOTIF GIVE CHARM TO SCREEN OR MURAL.

This means a study as wide as the birds' range and as endless as the constantly changing activities of man. His alteration of the character of the country, planting of new crops, introduction of foreign species, all produce new ecologic conditions calling for constant study of the native fauna.

This situation cannot be easily treated in a museum exhibition, so we have selected the Food of Birds as a subject in which we can illustrate the greatest service birds render man. From the ranks of the Insect-, Seed- and Rodent-eaters and the scavengers we have chosen small representative groups to show the nature of their food and method of securing it. The air-feeders include both nocturnal as well as diurnal birds; Swallows, Swifts, and Nighthawks among the latter, the Whip-poor-will and Chuck-wills-widow among the former. All are almost exclusively insectivorous.

The Redstart is a good connecting link between those birds that feed wholly on the wing and those that, like Flycatchers, make sallies from a perch to which they return.

Vireos, Warblers, Thrushes and Wrens are gleaners from tree-top to earth and are particularly valuable in our gardens, a favorite resort for insects. If some of them add fruit to their fare they probably have earned it.

The seed-eaters, Sparrows, Goldfinch, Cardinal and many other members of the great Finch family, perform a service of incalculable value in destroying seeds of weeds that follow in the wake of cultivation. In "Useful Birds" Forbush lists 41 kinds of noxious seeds eaten by birds.

When we say "Rodents" we usually mean rats and mice, meaning chiefly the foreign species, for the presence of which man is responsible. But neither Hawks nor Owls ask the nativity of their prey. They take what they find and if they are hunting in man's haunts they are apt to capture the species that are more or less parasitic on man. Farther afield they may get a larger proportion of native species; but all are destructive unless held in balance by nature's means.

There is a widespread prejudice against Hawks and Owls, but if we except the Great Horned Owl, Cooper's and the Sharp-shinned Hawk, we are safe in accepting the remaining commoner members of these families as friends rather than as foes.

The food of most water-frequenting birds is somewhat beyond our present limits but the Gulls, scavenging along our coasts, take the edible refuse from our shores and waters; while the Black Vulture and Turkey Buzzard are equally valuable on the land. The impossibility of presenting here anything like an adequate exhibit showing the economic relations of birds and man is obvious. It is hoped, how-

ever, that some conception of the extent and importance of the subject may be gained from the appended summary.

ECONOMIC RELATIONS OF BIRDS TO MAN

A. *Beneficial Relations.*
   Feeding on injurious insects, seeds and rodents; scavenging.
   Pollination of plants.

B. *Harmful Relations.*
   Destructive to grains, crops, fruits.
   Destroyers of beneficial insects and birds, fowls.
   Devourers of fish, chiefly in hatcheries.
   Distributors of disease-bearing parasites.

ECONOMIC RELATIONS OF MAN TO BIRDS

A. *Beneficial Relations.*
   (a) Intentional
      Protection by law and creation of a conserving sentiment: bird study in schools and colleges.
      Enlarging and improving all-season habitats; increasing food supply.
      Creation of refuges.
      Preparing nesting-sites and boxes; maintaining feeding stations and baths.
      Organized study of ecology.
      Development of domestic breeds.
   (b) Unintentional
      Planting crops and raising fruit on which birds feed.
      Leaving undergrowth that may serve for nesting sites, shelter and food.
      Irrigation; parks; lawns.
      Garbage dumps.
      Destruction of predatory birds and mammals.

B. *Harmful Relations.*
   (a) Intentional
      Killing for flesh or feathers for self-use or sale, or for other reasons.
      Killing for sport.
      Killing in defense of crops, etc.
      Trapping.
      Egging.

SECTION VI

ECONOMIC ORNITHOLOGY I

(See opposite page)

Barn Swallow.

Chimney Swift.

Redstart.

White-breasted Nuthatch.

Red-eyed Vireo

Downy Woodpecker.

Yellow-billed Cuckoo.

Flicker.

Tree Sparrow.

Red-shouldered Hawk.

Goldfinch.

Screech Owl.

Cardinal.

Black Vulture.

Herring Gull.


ECONOMIC ORNITHOLOGY I
THE FOOD OF BIRDS
THE INSECT EATERS
THE SEED EATERS
THE BILLS OF SPARROWS AND OTHER HARD-BILLED BIRDS SERVE AS CRACKERS OR CRUSHERS AND ENABLE THESE BIRDS TO FEED ON SEEDS WHICH MIGHT PRODUCE WEE RIOUS TO AGRICULTURE. EXAMPLES ARE THE CARD EE, SONG AND OTHER SPARROWS.
THE RODENT EATERS
RATS, MICE AND OTHER INJURIOUS SMALL RODENTS ARE DESTROYED BY OWLS AND HAWKS AND SOME OTHER BIRDS.
THE SCAVENGERS
WHERE MAN HAS NOT DEVELOPED EFFECTIVE METHODS OF GARBAGE DISPOSAL, SCAVENGERS, LIKE VULTURES AND GULLS, RENDER HIM VALUABLE SERVICE. EXAMPLES ARE THE BLACK VULTURE, TURKEY BUZZARD AND HERRING GULL.

(b) Unintentional

Increasing human population, new settlements, with consequences.

Alteration of haunts by deforestation, drainage, stream pollution, discharge of oil on coastal waters.

Use of poisons for insects or rodents, etc.

Predatory house cats; rats.

Introduction of competing birds; sparrows; starlings.

Erection of obstructions to flight.

References

1907. Forbush, E. H. Useful Birds and Their Protection. (Massachusetts Board of Agriculture.)

1927. Henderson, J. The Practical Value of Birds (Macmillan).

1933. Storer, T. I. Relations Between Man and Birds in California. The Condor, pp. 55-59.

Section VII

ECONOMIC ORNITHOLOGY II

DOMESTICATION

It is not improbable that the domestication of birds began when man first established a permanent home for himself. He could then care for an injured or young bird that chanced to come into his possession. If the bird accepted human association and became, as it were, a member of the family, the first stage in its domestication was passed. But there was a limit to man's hospitality. Birds that were wholly dependent on him for food were less desirable than those that in part, at least, could care for themselves. A chicken, for example, might scratch up a living about its home, or a duck might seek its fare in the mud and waters of a neighboring marsh, while both could find protection near man for the night. Their habitat and food were thus so natural that they mated with other individuals of their kind, tame or wild, and produced young which accepted as normal their parents' association with man. This is the second stage in our possible history of domestication. As further requirements the bird should be big enough for both its body and eggs to make a worth while source of food, and it should be fecund. If its feathers were useful, so much the better, but this was not indispensable.

These are the elements of successful domestication in the country of which the bird is a native. But to fulfill all the possibilities of domestication the bird should be prepared to live in any part of the world inhabited by man.

It is a common experience to see, for example, Chachalacas, Guans and Tree Ducks in their own land as tame as barnyard fowls; but they would not stand climatic change and their economic value is therefore limited by the extent of their range.

When, therefore, we consider the essentials of temperament, edibility, fertility and adaptability that enter into the making of a wholly successful domesticated bird we discover that there are surprisingly few kinds of birds that possess them all. The Jungle Fowl, Lag Goose and Mallard from the Old World, the Musk Duck and Turkey from the New, are the only ancestral forms that really deserve a place on our list. Peafowls, Guinea Fowls and Swans are not to be classed with them. Pigeons hold a quite different relation to man. Let us briefly consider all these birds in the order named.

The Chicken. – The Chicken, or Barnyard Fowl, stands at the head of our list of domesticated birds. Descended from the Red Jungle Fowl *(Gallus bankiva)* of Eastern India, Burma, Siam and Sumatra, early home of the human race, it seems probable that the Chicken was the first bird to be domesticated by man.

The Chicken possesses in a highly developed degree all the essential qualifications of domestication. To them it adds a lust for fighting which has endeared it to man and may have played no small part in promoting its domestication. No other bird has the aggressiveness and courage of the game cock. No other sport has had a larger following than cockfighting. It is within range of both rich and poor and has at times exerted so wide and undesirable an influence that it has been suppressed or prohibited by law.

In view of the countless varieties of fowls that are believed to have originated from the Jungle Fowl, it is remarkable that the Game Fowl should still resemble its ancestor. But as much care has been taken to preserve its original characters as to develop and establish those of its promising variants. Wherever the hen is found there may appear mutants or "sports" from which new races are bred. Among the better known are the Brahmin and Cochin from Asia, the Leghorn from Italy, the Houdan from France, the Dorking and Orpington from England, the Plymouth Rock and Rhode Island Red from North America and, as late as 1914, the Araucana, a race of unknown origin, was discovered in Chile. It is rumpless, has eartufts, and lays blue eggs. Who knows whence the next new race will come?

Directed by the laws of inheritance which a study of Mendelism and genetics has revealed, we may now hasten the processes of nature by definitely directing them. So remarkable have been the results attending this type of applied ornithology that governments, state and agricultural colleges, now have thousands of students experimenting in

Section VII

ECONOMIC ORNITHOLOGY II

ANCESTRAL FORMS OF DOMESTIC BIRDS

(See opposite page)

Peacock.
India, including Ceylon, eastward through Malay Peninsula to Java.

Rock Dove.
A Typical Homing Pigeon. (The Homer is shown because of its importance.)
British Isles to North Africa, Burma and China.

Jungle Fowl.
(Cock and Hen.)
Indian-Malayan region.

Guinea Fowl.
Africa and Madagascar.

Mallard.
Northern Hemisphere.

Musk Duck.
Tropical America.

Grey-Lag Goose.
Northern Europe to Eastern Asia.

Mexican Turkey (Hen).
Mexican Tableland from Chihuahua to Colima.


ECONOMIC ORNITHOLOGY II
DOMESTICATION
PIGEON
SELECTIVE BREEDING HAS DEVELOPED MORE VARIETIES OF DOMESTICATED PIGEONS THAN HAVE BEEN DERIVED FROM ANY OTHER BIRD. ALL ARE BELIEVED TO HAVE DESCENDED FROM THE WILD ROCK PIGEON
OF WHICH THE 14 RECOGNIZED SUBSPECIES ARE DISTRIBUTED IN THEIR RESPECTIVE RANGES FROM THE BRITISH ISLES TO NORTHERN AFRICA, BURMA AND
GUINEA FOWL
MALLARD
THE MALLARD (ANAS PLATYRHYNCHOS)
NORTHERN HEMISPHERE.
KNOWN IN NATURE.
AND DOES NOT FLY.
THE ROUEN, AYLESBURY, CALL, HOOKED-BILL
ED, AND PENGUIN DUCKS ARE POSSIBLY MUTANTS
THE DOMESTICATED MALLARD
BREED. ALL HAVE CURLY-TIPPED CENTRAL TAIL-FEATHERS.
MUSK DUCK
GOOSE
THE WILD ANCESTOR OF THE DOMESTIC GOOSE IS THE GREY-LAG GOOSE (ANSER ANSER), AN OLD WORLD SPECIES WHICH, IN NATURE, NESTS FROM ICELAND TO EASTERN ASIA. THERE IS ONLY ONE FORM OF THE DOMESTIC RACE. IT VARIES IN COLOR FROM GRAY TO WHITE AND IS HEAVIER THAN THE WILD SPECIES.
TURKEY
NORTHEAST MEXICO. 4. MERRIAM'S WILD TURKEY (M. G. MERRIAMI), SOUTHERN COLORADO, MTS. OF ARIZONA TO NORTHERN MEXICO. 5. MEXICAN WILD TURKEY (M. G. GALLOPAVO), MEXICAN TABLELAND FROM CHIHUAHUA TO COLIMA.
YARD BIRD IS DESCENDED FROM NO. 5, THE MEXICAN RACE. IT WAS FOUND DOMESTICATED BY THE EARLY SPANIARDS AND BY THEM BROUGHT TO SPAIN. IT REACHED ENGLAND AS EARLY AS 1524 AND LATER WAS BROUGHT BY ENGLISH COLONISTS TO NORTH AMERICA. THE DOMESTIC BIRD HAS THE TAIL AND TAIL COVERTS TIPPED WITH WHITE; IN THE EASTERN WILD BIRD THEY ARE
WERE 8,567,000

well-equipped laboratories where comparatively few years ago only the commercial breeder was working blindly in the poultry yard. The marvel of today will soon be the commonplace of tomorrow, and it will in turn be succeeded by conditions we cannot even imagine. The United States has taken the lead in this practical biology. Already the annual value of the hen and its eggs is over a billion dollars, and H. R. Lewis, writing in the *National Geographic Magazine* for April 1927, states that poultry products rank sixth in our annual agricultural income, and if one may judge the future by the past, they will in due time take first place.

The hen owes much to her egg. In 1937, the U. S. Department of Agriculture tells us that the value of hens' eggs was double that of their flesh, and in view of the enormous increase in egg-laying production for which the breeders and raisers of hens are responsible, it seems probable that no small part of the hen's increase in value will be made as an egg-layer.

We see now the importance of having selected a fertile bird in the beginning. Assuming that the wild Jungle Fowl had two broods annually, it produced about 25 eggs yearly. Compare that with the exceptional record of a British Columbia hen that laid 351 eggs in 365 days and the possibilities of the future are apparent.

Goose. — There is a wide difference between the Gamecock and the Gander but they agree in accepting the conditions of domesticity imposed by life with man. That is, they will abandon the forest or marsh for the barnyard. The Goose is neither a fighter nor a fertile egg-layer, but it has a large body of highly edible flesh, it bears a quantity of valuable down and its quills long supplied the world with pens (Sec. III). Geese are herbivorous and may be driven to pasture by a gooseherd.

The Gray Lag Goose *(Anser anser)*, from which the Domestic Goose has descended, ranges from Iceland to Eastern Asia. If the possibility of human contacts are indicated by the extent of its distribution, it may have been domesticated at several places independently. There is but one race of Gray Lag in nature and the common domestic goose differs from its wild progenitor only in being larger, more fecund and locally whiter. Other forms of the domestic goose are the Toulouse, the Brown and the White Chinese, the Embden and Gray African. There is a domesticated descendant of the Egyptian goose *(Chenalopex aegyptiacus)* which is found in Europe, north to Scotland. It resembles its ancestor.

The Canada Goose *(Branta canadensis)* seems to be on its way to complete domestication but at present it lives with man sporadically and is raised chiefly for parks and as decoys. It crosses with the Gray

Lag. The wild form is somewhat variable, several races being known. The tame bird resembles its ancestor.

Mallard. — The Mallard *(Anas platyrhynchos),* most widespread of ducks, inhabits the greater part of the Northern Hemisphere, southward in winter, in the Old World, to India, in the New, to Panama. The Mallard readily associates with man, and in a few generations a maimed wild bird will become too heavy to fly and will join other ducks in the barnyard. In a sense, therefore, we see domestication taking place before our eyes.

In spite of its great range, the Mallard is a remarkably stable bird. In nature, only two races are known. Under the varying conditions of domestication, however, it has given rise to a number of birds and varieties including the Runner, Aylesbury, Rouen, Penguin, Buff and Pekin. The latter, an all-white duck, was introduced into the United States from Shanghai in 1873 and is now widely raised here. In all descendants of the Mallard, the drake has the four recurved tail-coverts shown by the parent species.

It is said that the wild Mallard is monogamous, while the tame Mallard is polygamous, a change in habits possibly due to the more crowded life of the barnyard.

The Mallard is prolific and is therefore of value to man, not only for its flesh but also for its eggs.

The Musk Duck *(Cairina moschata),* miscalled Muscovy Duck, *Pato Real* of the natives, is found in the American Tropical Zone from northern Tamaulipas, Mexico, south to central Argentina. There is but one race in nature. It is a tree-inhabiting duck but in domestication loses the power of flight and becomes terrestrial. The Musk Duck differs from the Mallard in having a bare space about the eye, no recurved tail-coverts, and it does not quack; nevertheless, it hybridizes with the Mallard, a fact that doubtless accounts for the number of variations it shows when domesticated.

Turkey. — Cortez found the domesticated Turkey *(Meleagris gallopavo gallopavo)* in the possession of the Aztecs, and the specimens of it that he sent back to Spain have proved to be of greater value to the world than all the other treasure he secured in Mexico. From Spain, the Turkey is said to have reached England as early as 1541. It soon became established in England and thence accompanied the colonists to New England to serve as food on the voyage and in their new homes.

This, in outline, is the story of the introduction of the domesticated Turkey into the United States. But the history is far from complete. At the time the Mexican bird reached this country from England the Eastern Wild Turkey was a common bird in the Eastern United States as far north as southern Maine. So far as we know, it had not been

domesticated, and it was the bird brought from England that the colonists put in their poultry yards. There its descendants remain, but the Wild Turkey is now extinct in New England, indeed is not found north of central Pennsylvania and only locally southward.

Fortunately for the student of their history, the Mexican Wild Turkey and the Eastern Wild Turkey differ in color from each other enough to be distinguished at sight. The Mexican bird and its domesticated descendants have the tips of the tail and of the tail-coverts whitish (see the female in the group and photograph) while in the Eastern Wild Turkey these parts are chestnut. But as we go from one country to the other we find that these characters gradually change and the two extremes are connected by intergrades; a good example of subspecific geographic variation. Thus, beginning at the South, we have: (1) Mexican Wild Turkey *(Meleagris gallopavo gallopavo),* Mexican Tableland from Colima to Chihuahua. This is the ancestral race. (2) Moore's Wild Turkey *(M. g. onusta),* western slopes of the Sierra Madre in southeastern Sonora and Sinaloa. (3) Merriam's Wild Turkey *(M. g. merriami),* southern Colorado to mountains of Arizona and northern Mexico. (4) Sennett's Wild Turkey *(M. g. intermedia),* middle Texas to northeastern Mexico. (5) Florida Wild Turkey *(M. g. osceola),* southern Florida. (6) Eastern Wild Turkey *(M. g. silvestris),* eastern Texas and northern Florida, locally, to central Pennsylvania.

In domestication, Turkeys vary in color from black to white, six varieties being recognized. At present the experimental Bureaus of the United States Department of Agriculture are breeding a turkey small enough to be roasted in the average apartment-house oven. According to this Department, on January 1, 1940, there were 8,567,000 turkeys on our farms, valued at $18,679,000.

Peacock. – Peacocks are found from India, including Ceylon, eastward through the Malay Peninsula to Java. There are two species, *Pavo cristatus* and *P. muticus.* The former is the more common and is the ancestor of our lawn bird. A mutant race of *P. cristatus,* called *Pavo nigripennis,* appears only in domestication and may at times revert to the parent stock. White individuals occasionally occur.

The Peacock does not take well to domestication. It seems to consider itself superior to the usual barnyard fowl; moreover it is not fertile. Doubtless, without the attractions of its marvellous plumes, it would not have found its way with man.

The Peacock and Jungle Fowl are natives of the same region where they both have doubtless been associated with man from the period of their domestication. The former is chiefly ornamental and has a limited place in man's economy. The latter is the most valuable animal in the world. Nevertheless, the Peacock, and not the fowl, is mentioned

in the Old Testament and as the bird of Juno it had a place in Grecian mythology that the humble fowl was not given.

If the Peacock's tongue formed part of Roman feasts, it was evidently display of wealth rather than palatability that gave it a place as food.

Guinea Fowl. — The Guinea Fowl is said to have descended from *Numida meleagris* of west central Africa. Although there are 21 races of this bird extending eastward to Madagascar, the domesticated bird shows but little variation, a tendency to whiteness being its principal change from its ancestor.

The Guinea Fowl never becomes thoroughly familiar with man and its excited cry of alarm when disturbed is a familiar note. Where the surroundings are favorable, it is apt to run wild. Then it is hunted as a game bird.

Pigeon. — Darwin's belief that the Rock Pigeon *(Columba livia)* is the ancestor of the Domestic Pigeon and its many breeds and varieties is still the prevailing opinion. This fine bird, represented by 14 subspecies, ranges from Great Britain south to northern Africa east to China. In spite of the countless races to which it has given rise, individuals that essentially resemble the parent form are still frequently found among our domestic birds.

Aside from its distinguished place in the past, the Pigeon of today holds increasingly important relations with man. To the pigeon fancier the bird gives a hobby or occupation of world-wide interest with the development of the Homing Pigeon as its outstanding achievement. Signals, telegraph, telephone, radio yield more and more effective service, but the Homer still fills a unique place as a means of communication among men. Both adult and young Pigeons occupy growing space in our markets. In the laboratory the birds are the faithful servants of research.

But comparatively few of us know much about variation and inheritance, artificial selection and breeding, or the raising of squabs, and fewer still conduct experiments in genetics. But we all see the pigeons of our parks and the cliffs of our skyscrapers who own no master. They are really worth more to man than those of all the other classes combined. They come to our window sills, feed on the lawns at our feet, or perch on our hands or shoulders. They are free to come and go, or to fly for the joy of flying, but their confidence in us makes them part of our lives.

The earthbound mind may protest against the use of our walls and roofs and the crevices that architects have so fortunately, but so unwittingly provided, but to him who rejoices in the birds' sweeping

circles overhead and lightning flashes past our windows, their wings spell freedom.

References

1868. Darwin, C. The Variation of Animals and Plants Under Domestication. 2 vols. John Murray, London.

1927. Jull, Morley A. The Races of Domestic Fowl. 96 illus., 29 in color. Nat. Geog. Mag., Vol. 51, No. 4, April, pp. 379-452.

Lewis, Harry R. America's Debt to the Hen. 15 illus. Nat. Geog. Mag., Vol. 51, No. 4, April, pp. 453-467.

1930. Jull, Morley A. Fowls of Forest and Stream Tamed by Man. 43 illus., 16 colored. Nat. Geog. Mag., Vol. 57, No. 3, March, pp. 327-371.

1941. Levi, W. M. The Pigeon. R. L. Bryan, Columbia, S. C. Indispensable to the pigeon-minded.

Section VIII

ECONOMIC ORNITHOLOGY III

In this section we have placed facts and feathers which bear little or no relation to one another but are closely related to man.

Flight. — It may be argued that man never would have flown without the example of birds to stimulate his imagination and arouse his ambition. Certain it is that the earlier aëronauts took the birds as a model. Lilienthal lost his life in the attempt to fly like a bird. The subject of birds' flight will be treated elsewhere in this hall, but we pause here to pay a tribute to him as one of a band of fearless adventurers who tried to conquer the air.

The Feather Trade. — From the beginning of their contact with man birds have been cursed by their flesh and their feathers. The former was perishable and the market correspondingly restricted. The latter are light, easily transportable, long-lived. They could be safely sent from the most remote parts of the earth. From milliner to hunter, the trade was strongly organized. Paradise plumes were fashionable in London and in New Guinea; aigrettes were the mode in Paris and on the Orinoco. The birds of our gardens were not spared.

Perhaps in no other one way can our change of heart toward birds be more convincingly shown than by comparing the trimming of the hats of today with those of over fifty years ago. Here is a list of the species of birds I saw on women's hats in 1885 on Fourteenth Street, then the shopping district of New York.

Robin, four	Blackburnian Warbler, one
Brown Thrasher, one	Blackpoll Warbler, three
Bluebird, three	Swallow-tailed Flycatcher, one

Kingbird, one	Purple Grackle, five
Kingfisher, one	Blue Jay, five
Pileated Woodpecker, one	Flicker, twenty-one
Red-headed Woodpecker, two	Saw-whet Owl, one
Wilson's Warbler, three	Mourning Dove, one
Scarlet Tanager, three	Prairie Hen, one
Tree Swallow, one	Ruffed Grouse, two
Bohemian Waxwing, one	Bob-white, sixteen
Cedar Waxwing, twenty-three	California Valley Quail, two
Northern Shrike, one	Sanderling, five
Pine Grosbeak, one	Greater Yellowlegs, one
Snow Bunting, fifteen	Green Heron, one
Tree Sparrow, two	Virginia Rail, one
White-throated Sparrow, one	Laughing Gull, one
Bobolink, one	Common Tern, twenty-one
Meadowlark, two	Black Tern, one
Baltimore Oriole, nine	Grebe, seven

Today, if you can find one of these on a hat in any shopping district in this city or elsewhere, and can name the offender, I am sure that the Audubon Society will arrest her and reward you.

In America, organized bird study was the first step in the control of the feather trade. You cannot arouse support for a cause that is only a name. On September 26, 1883, the American Ornithologists' Union was formed. Two years later it gave birth to the first Audubon Society. From that seed have grown the flourishing conditions of today.

Condor. — Recently there was an attempt to revive the fashion of wearing large quills, among them those of the Condor. It was quickly suppressed by the Audubon Society.

Some years ago a Condor hunter, whom I met in Mendoza, Argentina, at the foot of the Andes, told me that he had sent the wings and tails of 16,000 Condors to milliners in Paris. For them he had received twenty dollars gold per bird. Because of the war, the price had fallen to ten dollars per bird. This fact thoroughly aroused the hunter's indignation and with fine dramatic display he said, "I refuse to take part in the destruction of such a noble bird for such a low price!"

Swan. — Powder-puffs are in themselves harmless things but countless swans have been killed to supply them. A Museum man reports finding the skins of hundreds of thousands of Black-necked Swans awaiting shipment in an Argentine warehouse.

The Rhea as a Feather Duster. — A Rhea that gives its life to prevent a Tehuelche from starving, dies a not unworthy death (Sect. I); but a Rhea that is killed to make a feather duster is shamelessly sacri-

Section VIII

ECONOMIC ORNITHOLOGY III

(See opposite page)

Otto Lilienthal.
Born, 1848; Died, 1896.

Egret plumes still attached to the skin.

Bird of Paradise.

Condor Wing Quill.

Powder Puff.

Fish "Flies."

New Hebrides Money.

Feather-duster.

Egger on Bempton Cliff.
(Man at end of rope in middle of picture.)

Murre's Egg.

Chilean Pelicans nesting on island off Peru.

Tame and Wild Canary.

Fishing with Cormorants.

Guano Fleet off Chincha Is., Peru, in 1860.

Gray Partridge.

Starling.

House Sparrow.

Ring-necked Pheasant.
(Female and Male.)


ECONOMIC ORNITHOLOGY III
OTTO LI ENTHAL
BORN, 1848; DIED, 896
NSPIRED BY THE FLIGHT OF BIRDS HE WAS A PIONEER IN MAN'S FINALLY SUCCESSFUL EFFORT TO MASTER THE AIR
THE FEATHER TRADE
MAN'S USE OF BIRDS FOR ... EXCEEDED BY HIS DEMAND FOR THEIR FEATHERS. ... RUTHLESS DISREGARD FOR LIFE HE HAS SCOURED THE EARTH FOR BIRDS BEARING SALEABLE PLUMAGE. NATIVE HUNTERS WERE HIS AGENTS; ... TOMERS. SO DESTRUCTIVE WAS THIS TRADE THAT ... TIMS HAVE BEEN SAVED FROM EXTERMINATION ONLY ... THE ORGANIZATION OF BIRD PROTECTION.
IN THIS COUNTRY THE TRAFFIC IN FEATHERS HAS NEARLY CEASED; ELSEWHERE IT IS NOW CONTROLLED. IN A FEW CASES, NOTABLY OSTRICH, ... AND EIDER, THE FEATHERS USED ARE TAKEN FROM ...
NATIVE BIRDS WHOSE FEATHERS WERE SEEN ... HATS IN 14TH STREET, NEW YORK C...
CONDOR WING QUI
FISHING "FLIES" OF FEATHERS
PARADISE BIRD OF NEW GUINEA REGION
POWDER PUFF
OF RHEA FEATHERS
BIRDS' EGGS
INCALCULABLE NUMBERS OF THE EGGS OF WILD BIRDS HAVE BEEN GATHERED FOR FOOD. WHEN THEY WERE COLLECTED ONLY DURING THE FIRST PART OF THE LAYING SEASON, AND THE BIRDS THEN LEFT UNDISTURBED, THE SUPPLY WAS MAINTAINED. EGGS ARE ALSO COLLECTED BY OOLOGISTS.
GUANO
OCEANIC ISLANDS IN RAINLESS AREAS MAY SERVE AS THE HOME OF CERTAIN SEA-BIRDS. FEEDING ON FISH, THEY TRANSFORM IT INTO FERTILIZER. THE MOST FAVORABLE CONDITIONS FOR THE PRODUCTION OF THIS GUANO EXIST OFF THE COAST OF PERU. THE BIRDS THAT PRODUCE IT ARE CORMORANT, BOOBY AND PELICAN. THE AVERAGE VALUE OF THEIR YEARLY DEPOSIT IS OVER SEVEN MILLION DOLLARS. THE TOTAL VALUE OF THE GUANO MINED THERE, INCLUDING THE ORIGINAL DEPOSIT, IS ABOUT ONE BILLION DOLLARS.
WILD CANARY
AZORES
BIRDS AS PETS
BIRDS' VOCAL GIFTS, BEAUTY, FRIENDLINESS AND VITALITY CREATE A UNIVERSAL DESIRE FOR THEIR COMPANIONSHIP. FROM THE MOST PRIMITIVE TO THE MOST CIVILIZED MAN BIRDS ARE, THEREFORE, VALUED AS PETS. WHEN THEIR TEMPERAMENT AND SURROUNDINGS PERMIT, THEY MAY BE FREE; BUT IN MOST INSTANCES THE NEED FOR CONFINEMENT AND PROTECTION COMPELS THE USE OF A CAGE. THIS MAY HOUSE ONLY ONE BIRD OR THE SEEMING LIFE OF AN AVIARY.
THE INCREASING DEMAND, BOTH LOCAL AND FOREIGN, FOR MOCKINGBIRDS, CARDINALS AND OTHER AMERICAN BIRDS AS PETS, RESULTED IN THE PASSAGE OF A LAW PROHIBITING THEIR CAPTURE. IN THIS COUNTRY, THEREFORE, ONLY FOREIGN BIRDS MAY BE LEGALLY CAGED. WITH THEM IS INCLUDED THE SEMI-DOMESTICATED CANARY OF WHICH, IN 1920, WE IMPORTED 589,251. BELIEVED TO HAVE BEEN INTRODUCED INTO EUROPE FROM THE CANARY ISLANDS ABOUT 1550, BIRD-BREEDERS HAVE SINCE DEVELOPED MANY VARIETIES.
FISHING WITH CORMORANTS
IN CHINA AND JAPAN CORMORANTS ARE USED TO CATCH FISH. THE BIRD IS HELD CAPTIVE BY A LEASH AND A BAND AROUND ITS NECK PREVENTS IT FROM SWALLOWING THE LARGER FISH.
EXTINCTION INTRODUCTION
SINCE WHITE MAN HAS INHABITED NORTH AMERICA THE FOLLOWING BIRDS HAVE BECOME EXTINCT: PALLAS' CORMORANT, GREAT AUK, LABRADOR DUCK, HEATH HEN, ESKIMO CURLEW, PASSENGER PIGEON AND CAROLINA PAROQUET.
ON THE OTHER HAND, HE HAS INTRODUCED THE HOUSE SPARROW, EUROPEAN GOLDFINCH, EUROPEAN STARLING, ENGLISH PHEASANT, GRAY PARTRIDGE AND LESS NOTABLE SPECIES TO OUR FAUNA. BIRDS WHICH MAY BE HARMLESS IN THEIR NATIVE COUNTRY MAY BECOME OVERABUNDANT AND UNDESIRABLE WHEN INTRODUCED INTO OTHER COUN... A FAMILIAR EXAMPLE IS THE HOUSE SPARROW WHICH
WAS FIRST BROUGHT TO AME... AND RELEASED IN BROOKLYN, NEW YORK. IN ... INTRODUCED INTO NEW YORK CITY AND IS ... THROUGHOUT THE GREATER PART OF THE WES... SPHERE.
THE EUROPEAN STARLING WA... INTRODUCED INTO AMERICA IN ... IT IS NOW (1942) FOUND ... NEVADA.
THE PRESENCE ... AS GAME BIRDS, ... MISSIONS.

ficed for an ignoble purpose. The extent of the trade in Rhea feathers threatens the bird's extinction. Sixty tons of them were found in a single Buenos Aires warehouse, bound for New York, by a museum representative.

It appears that in the Argentine the Rhea is called "Avestruz" or Ostrich, and as our laws permit the importation of Ostrich plumage, no way has yet been discovered to prevent the entrance of Rhea feathers into this country.

Birds' Eggs. — Man has levied not alone on domesticated, but on wild birds for their eggs. Murres, Gulls and Terns that nest in colonies are most often preyed on. If the eggs are gathered only during the early part of the laying season and the birds are then unmolested, no harm may be done and a natural asset is wisely used. But when Gulls are present in numbers they rob the exposed nests of other birds without regard to season and with disastrous results. In this way the Murres of the Farallone Islands, that once supplied San Francisco with eggs, have been driven from the islands.

Guano. — Certain sea birds living on oceanic islands feed on fish and transform it into guano, the fertilizing properties of which are retained in rainless areas. The most notable examples of these conditions are found on islets in the Humboldt Current off the coast of Peru. There, the annual deposit of countless Cormorants, Boobies and Pelicans, wards of the Peruvian Government, is valued at over seven millions of dollars. It is estimated that the value of the entire deposit found there is about one billion dollars.

Fishing with Cormorants. — In both China and Japan fish form a staple diet and Cormorants are employed for their capture.

The bird is held captive by a leash but is given sufficient freedom to pursue its game. A band or ring around its neck permits it to swallow only its smaller prey. This custom was at one time followed in England.

Birds as Pets. — Birds' vocal gifts, beauty, friendliness and vitality create a universal desire for their companionship. From the most primitive, to the most civilized man birds are therefore valued as pets. When their temperament and surroundings permit, they may be free, but in most instances the need for confinement and protection compels the use of a cage. It may contain only one bird or the swarming life of an aviary.

The growing demand, local and foreign, for Mockingbirds, Cardinals and other American birds as pets, resulted in the passage of a law prohibiting their capture. In this country, therefore, only foreign birds may be legally caged. First among them is the Canary of which, in 1920, we imported, chiefly from Germany, 589,251 individuals. Be-

lieved to have been introduced into Europe from the Canary Islands about 1550, breeders have since developed many varieties.

Extinction: Introduction. — During the past century the following North American birds have become extinct: Great Auk, Labrador Duck, Guadalupe Caracara, Heath Hen, Eskimo Curlew, Passenger Pigeon and Carolina Paroquet. The Whooping Crane, Ivory-billed Woodpecker and several others are near extinction.

The conservationist arrived on the scene at too late a date to save any of the first seven of these birds; it is doubtful if he can preserve the last two. But he has learned of the diverse dangers to wild life that follow in man's wake. Not the least among them is the introduction of foreign species.

Fortunately, we have passed the day when everyone was free to introduce any bird that he pleased. The well-meaning philanthropist who, in 1864, released House Sparrows in Madison Square, New York City, continued to import foreign birds to the end of his life. Skylarks, European Goldfinches, Chaffinches and Song Thrushes were among his attempts to add to our bird-life. The Lark lived for a time and we still see an occasional Goldfinch. But it was not until 1890, when the importer had 60 Starlings freed in Central Park, that he laid the foundation for what he considered his second great success.

One must indeed be an enthusiastic bird-lover to find much that is admirable in the House Sparrow. But if the Starling were a native of this country and occupied its alloted place, I believe that it would be a popular bird. It is attractive in appearance, has interesting habits, has a musical and varied voice, is of some economic value and in the fall, when it spreads its scroll across the sky, it moves with marvellous precision. Thousands of birds act as one. There appears to be no leader; no note of command. How can we explain the community of feeling that controls them? It is a pure expression of *joie de vivre* which raises the industrious plotter to an ethereal realm where nationalities are unknown, and the glorious heritage of flight is the universal emblem of bird-life.

At present our attitude toward foreign species has so completely changed that it is more difficult for a bird than for a man to secure permission to enter this country. At the best, one cannot predict the part the newcomer will play. How can one tell what rivalries or disagreements it will arouse? Is there an unoccupied habitat awaiting it, or must it make one of its own at the expense of a native species?

There are no ready-made answers to these questions. "Yes" in one place may be "No" in another. Only an actual test will tell us whether we win or lose. In either event we should realize the risk that we are taking.

The English, or Ring-necked Pheasant *(Phasianus torquatus)*, has both foes and friends. The former claim that it is destructive to crops and an enemy to our native grouse. The latter say that its value as a game bird far outweighs any harm it may do. In any event, the removal of the laws that now protect it would effectively prevent its undue increase.

The much smaller European Partridge *(Perdix perdix)* has apparently found a favorable habitat in our plains and prairies and their grain-fields where, if desirable, its spread can always be controlled.

References

1917. Crandall, Lee S. Pets: Their History and Care. Illus. Henry Holt and Co., New York.

1926. Gudger, E. W. Fishing with the Cormorant in China. Amer. Nat., Vol. 60, pp. 5-41.

1929. Gudger, E. W. Fishing with the Cormorant in Japan. Scientific Monthly, Vol. 29, July, pp. 5-38.

1933. Leopold, Aldo. Game Management. Scribner's.

1936. Murphy, Robert Cushman. Oceanic Birds of South America. 2 vols. American Museum of Natural History, New York.

Section IX

THE SENTIMENT OF ORNITHOLOGY

The Song of Birds. – Birds exercise their greatest influence on the mind of man through their voice. It was their wild calls that reached the ear of savage man; it is their songs that stir our hearts today. How remarkable it is that the tiny syrinx of some inconspicuous, perhaps unseen, songster has the power to inspire the poets' noblest utterances! Poets, indeed, were the first ornithologists, as any anthology of bird verse proves. Long before the zoologist was describing and classifying, the poet was writing of the birds that he knew. Aristophanes preceded Aristotle; Shakespeare was nearly a century before Linnaeus. The naturalist's works are replaced by better ones. What the poet writes remains as he wrote it.

This section of our exhibit might well have followed Section IV, "Birds in Books." But it has been placed after, rather than before, "Economics" in order that we might end our review on a subject which we believe to express the highest relation between bird and man.

To the Hermit Thrush and Bobolink, shown under the Literature of Birds, we add here three more representative American songbirds,

the Mockingbird, Cardinal and Wood Thrush. Each one is a noted songster in his own right but when, some spring morning in the South, their voices are joined, one exclaims with Izaak Walton:

"Lord, what music hast Thou provided for the Saints in heaven, when Thou affordest bad men such music on earth?"

Bird Study and Conservation. — "Know your bird!" should be the motto of the bird conservationist. Before he ventures to apply the principles of his profession to the living bird he should have a thorough knowledge of it in its environment. This means not only its haunts but its neighbors. Few birds are wholly good and fewer still are wholly bad. It is for the conservationist to determine just where a bird stands in the economic scale and value him accordingly.

Here comes the need for education. The trained conservationist is a specialist to whom the legislator applies, or should apply, for expert advice before exercising his functions as a lawmaker. We begin, therefore, at the beginning and first learn our bird. This is the plan the Audubon Society (1006 Fifth Avenue) has long followed. Since 1911 it has enrolled over six million pupils in its Junior Bird Classes. From that start bird study has entered the colleges where courses have for years been given that prepare the student to serve either State or Federal Government as a professional conservationist.

The Friendship of Birds. — The window feeding-shelf makes a bond between bird and man that is valuable to them both. Birds' shyness prevents that close association which begets friendship, but when birds accept our hospitality and, as it were, break bread with us, then we have a feeling of intimacy with them that brings them definitely into our lives. Children, particularly, love to welcome birds and never tire of watching them; and the association thus begun lasts through the years.

Bird baths, especially in summer, may also be provided, and nesting-boxes will usually find tenants. The attractiveness of our gardens may also be increased by the proper kind of planting. There are many books that tell just how to do this.

The next step in making the world better for birds, and hence for man, is the bird sanctuary. Here we have a larger area, on selected ground, and exercise more complete control. In the adjoining hall of the Roosevelt Wing there is a Habitat Group of the Roosevelt Bird Sanctuary, established by the National Audubon Society at Oyster Bay, New York, in honor of a great bird-lover. Note particularly, at the left of the group, the original of a letter written by Colonel Roosevelt to the New York State Audubon Society in 1898 at the time of its foundation.

Section IX

THE SENTIMENT OF ORNITHOLOGY

(See opposite page)

Mockingbird. Cardinal. Wood Thrush.

Nuthatch.

Blue Jay. Downy Woodpecker.

Nuthatch.

Purple Finch Chickadee. Tree Sparrow. Junco.

Myrtle Warbler.

House Sparrow.

Bob-white. Junco.

THE SENTIMENT OF ORNITHOLO
THE POETS BECOME
HE "MOST ELOQUENT EXPRESSION OF
AND FREEDOM" IT WAS THEIR POWER
STIMULATED HIS AMBITION TO MASTER THE
AIR IT WAS THROUGH THEIR WILD CALLS THAT BIRDS CLAIMED
ATTENTION OF SAVAGE MAN; IT IS THROUGH THEIR SONGS THAT
THEY REACH OUR HEARTS TODAY.
IS THE BASIS OF
EFFORTS TO ATONE FOR HIS
FOR THE LIFE
THE AUDUBON
JUNIOR BIRD CLASSES IN
HAS SINCE ENROLLED OVER
WHERE COURSES ARE
WHICH PREPARE
TO SERVE EITHER
OR FEDERAL GOVERN
AS A PROFESSIONA
VATIONIST.
THE FRIENDSHIP OF BIR
LOVE OF BIRDS PROMPTS
TO MAKE FRIENDS WITH THEM.
WE OFFER THEM NESTING AN
BATHING PLACES IN SUMMER, AN
IN WINTER PROVIDE THEM WIT
FOOD AT OUR WINDOWS.
WITH OTHER BIRD-LOVERS
DEVELOP FAVORABLE AREAS
BIRD SANCTUARIES; SUCH, FOR
AMPLE, IS THE ROOSEVELT BI
SANCTUARY AT OYSTER BAY, BEAU
FULLY REPRODUCED IN THE ADJO
ING HALL.

LOOKING BACKWARD

Even in our own time there has been an almost unbelievable change in our relations to birds. Countless illustrations in proof of this statement will occur to every bird-lover. In my youth feeding-stands and bird baths were rare and interest in birds was largely limited to sportsmen and gunners. Primarily in their own behalf, they secured the passage of laws designed to protect game birds; "game laws" they were called, and game commissioners and game wardens were appointed to enforce them. Laws for the protection of song and insectivorous birds were as unknown as the birds themselves. These birds were shot at any season. Witness the list of hat birds in the preceding section. Compare the Quail in Sections I and IX.

Birds sang just as sweetly then as they do now, but we did not hear them. They were just as beautiful as they are today, but we did not see them. They were just as ready to make friends, but we did not heed them. It is man, not the birds, who has changed. The place that they have won in his life is a measure of his increasing awareness of his environment as birds have helped reveal it to him.

References

1916. Ladd, Neil Morrow. How to Make Friends With Birds. What to Do to Make One's Home Grounds Attractive to Bird Life. From Nesting Boxes to Winter Feeding. Doubleday, Page & Co.

1939. McKenny, Margaret. Birds in the Garden and How to Attract Them. Reynal & Hitchcock. New York.

1941. Baker, John H. (Editor). The Audubon Guide to Attracting Birds. Doubleday, Doran and Company.

The Archaeologist at work

How Science Deciphers Man's Past

By
CLARK WISSLER

THE AMERICAN MUSEUM OF NATURAL HISTORY

MAN AND NATURE PUBLICATIONS

The Archaeologist at Work

HOW SCIENCE DECIPHERS MAN'S PAST

By Clark Wissler

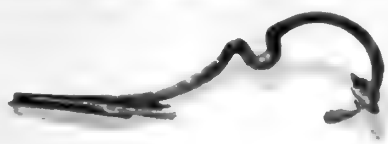
Science Guide No. 116

NEW YORK CITY
The American Museum of Natural History
1946

Reprinted from NATURAL HISTORY Volume LI, No. 3, 1943

HOW SCIENCE DE

A 3400-year-old safety pin, of bronze



The Archaeologist's Articles of Faith

A. That wherever man disturbs the earth as laid down by nature, the scar remains forever, or at least until nature re-deposits that portion of the earth's surface. Nature alone can wipe the slate clean, ready to record the next series of human events.

B. That when a group of people lives for a time upon the same spot, a deposit of refuse or debris accumulates, mostly ashes and bones, among which are scattered lost and discarded useful objects. If this deposit has not been disturbed unduly, the oldest objects will lie near the bottom, the latest at the top. If the original community abandons the site, nature spreads a coat of soil over all, and when another community makes the same site its home, a second layer of telltale refuse is laid down upon this black-soil cover, and so on, ad infinitum.

C. If the same people live on the same spot for centuries, the tools and other products of their workmanship—artifacts in the archaeologist's language—will show significant changes from the bottom of the refuse upward. Especially is this evident among those which are ornamented. The idea that we alone of all peoples and ages progress, or change, is pure conceit. It is the universality of change in the ways of human living which makes archaeology possible; these changes register the march of time.

D. Human communities are never isolated for long. They watch their neighbors and imitate them. So the order of artifacts in one refuse heap can be checked by another in a near-by site.

A rapid trip through the story of archaeology reveals how the Sherlock Holmeses of science have developed methods for solving the greatest mystery story of all

By Clark Wissler

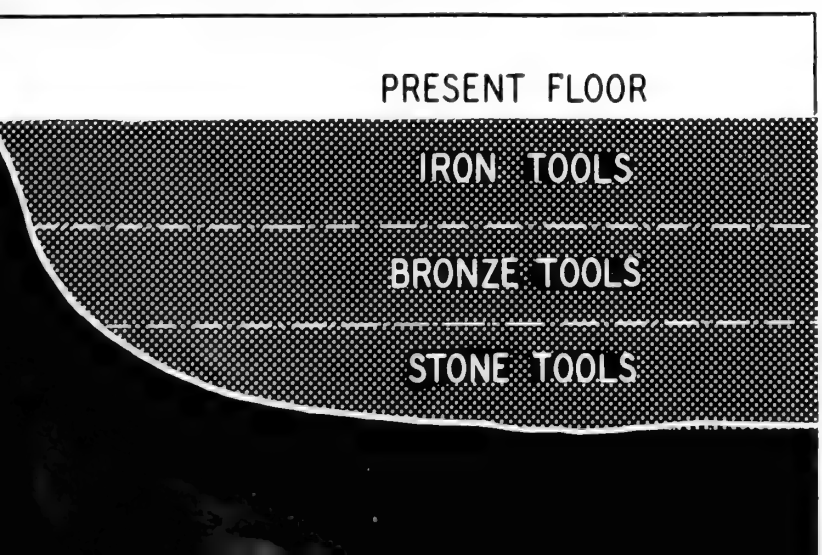
Curator Emeritus, Anthropology, American Museum of Natural History

A SKILLED archaeologist is the Sherlock Holmes of anthropology. The uncanny use he can make of faint traces in the earth where unknown human beings once lived is more fascinating than detective fiction. We believe you will enjoy looking in upon archaeologists at work.

The archaeologist has confidence in his methods. Some of his basic articles of faith are given at left.

With these principles in mind, the archaeologist faces his job, which is to discover what types of community living have existed in the world, where they existed, and in what time order. If the reader can keep these simple statements in mind he should have little difficulty in understanding the remainder of this article and in interpreting the pictures.

Cross section of a peat bed showing relative positions of objects belonging to the Iron, Bronze, and Stone Ages of Denmark. This principle of stratigraphy is the scientific basis of archaeology, first demonstrated by C. J. Thomsen in 1836



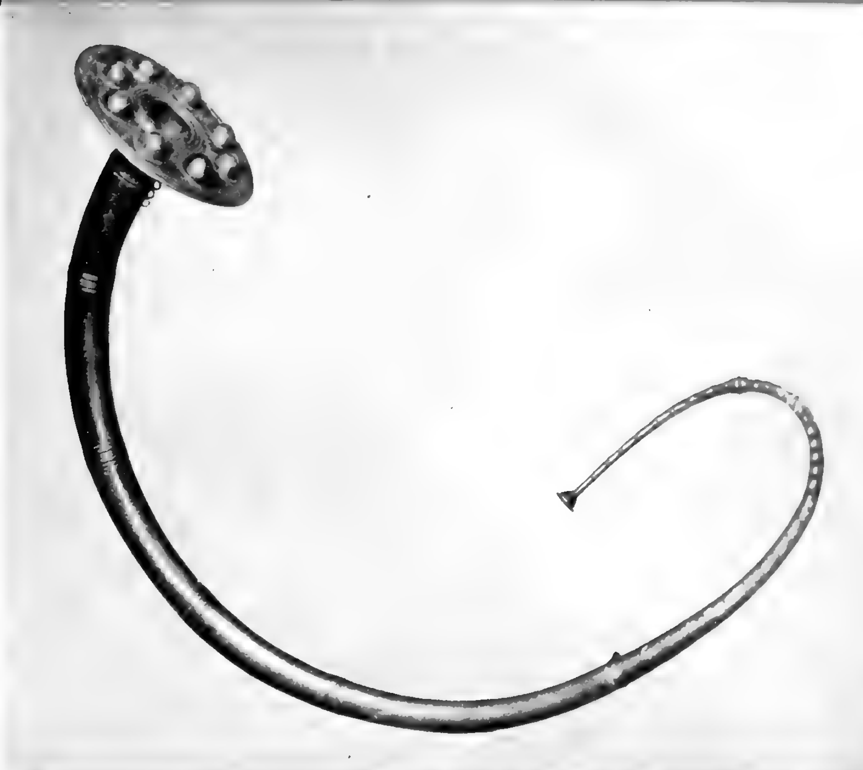
Sections in a shell heap showing alternate layers of shell refuse and sand. The man-made shell layers indicate time sequence from below upward. (Pickwick Basin, Tennessee River, Ala., T.V.A. Project, excavated by Major W. S. Webb)

IPHERS MAN'S PAST

When Archaeology Became a Science

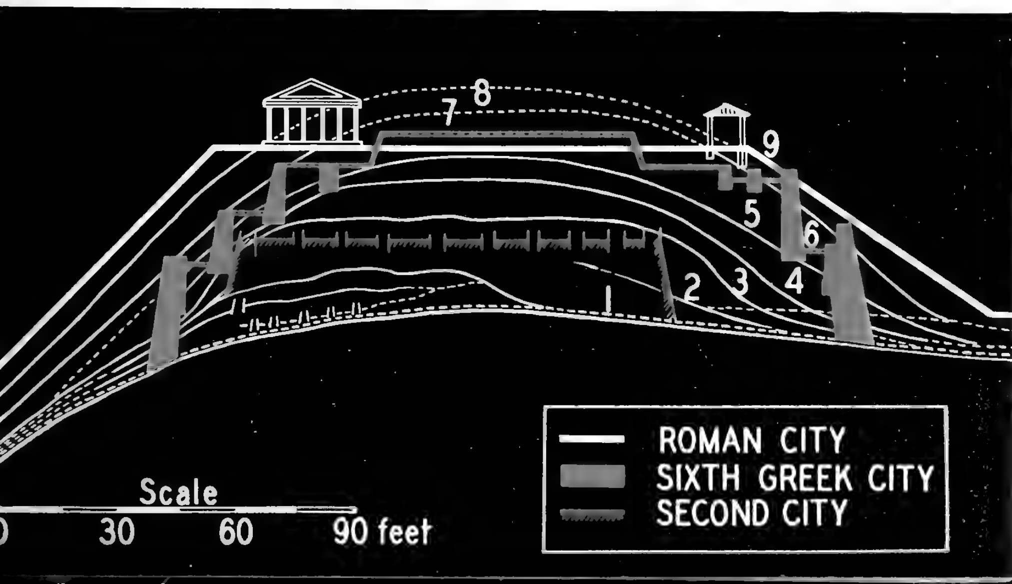
ABOUT 1830, C. J. Thomsen, curator in a Danish museum, was busily receiving and cataloguing curious objects turned in by laborers digging peat for fuel. These objects were of iron, bronze, and stone. There were axes of these three substances, shields of bronze, and swords of both iron and bronze, not to mention hundreds of small objects. In course of time, Thomsen began to wonder which of these objects were invented first. He knew that peat deposits were built up slowly from the bottoms of ponds and swamps.

One day it occurred to him that the depths of the objects found in the peat should tell the story. After keeping such records for a few years he had the answer: iron above, bronze objects next below, stone near the bottom. He published a paper about as long as this article telling how he knew once and for all that the historic age of iron in Europe followed a prehistoric age of bronze, and that the latter was preceded by an age of stone. On that day scientific archaeology was born. Armed with such a logical tool of crystal truth, the archaeologist could revolutionize the knowledge of man and the way of thinking about him.



THE MOST PRIZED Bronze Age relics are large bronze trumpets in such perfect condition that folk music can be played upon them. This one is in the American Museum of Natural History

↓ THE NINE CITIES OF TROY excavated by Schlieman in 1870-1875, the first use of scientific methods in a large site. His Sixth City proved to be Homer's Troy, 1500 B. C. See, *Troy, a Study of Homeric Geography*, by Walter Leaf. Also, *The Discovery of Man*, by Stanley Casson



Pottery as a Time Marker

BEFORE 1912 many museums and amateur collectors had ransacked ruins of cliff-houses and prehistoric Pueblo Indians in New Mexico and Arizona, because they were rich in beautiful pottery. The burning question was, when were these ruined structures built? The professors who lectured on the archaeology of the Old World were enthused by Thomsen's discovery of time sequence—Stone Age, Bronze Age, Iron Age—but here in New Mexico were neither bronze nor iron—merely things made of wood, bone, shell, stone, and pottery. The most conspicuous was pottery. In the neighborhood of every ruin one could see bits of broken pottery upon the ground—potsherds of many colors, all mixed together in profusion. Most of these sherds were of

thumbnail size and so numerous that a quart could be gathered in a few minutes.

There was a young curator in the American Museum who thought there should be some way to find the answer as to the age of the ruins. He consulted the then famous archaeologists of the country, but they said it could not be done, that they had tried and failed. Yet his faith was stubborn. He spent several seasons going about among these ruins. At first, he dug industriously within the walls of promising ruins, where he often found fine unbroken pots such as collectors prized, but the answer was not there. Then he noticed that immediately outside each ruin there was always a pile of ashes where the tidy prehistoric housekeepers dumped the sweepings from the family hearth, including other trash and especially potsherds.

This young curator was N. C. Nelson, now the Museum's distinguished senior archaeologist. We suspect that by this time the reader has guessed what Nelson had in mind; he believed that if he could find even a small section of an ash heap undisturbed by his pot hunting predecessors, the answer would be forthcoming. So Nelson went up and down the country picking up samples of the different kinds of sherds scattered round about a ruin, and doing a careful job of digging wherever he found the proper spot. In 1916 he published a short paper containing a time

A. M. N. H. Photo

POTSHERDS from a room in the Pueblo Ruin at Aztec, New Mexico. Over 2700 sherds were found in the debris filling this one room. Sorting and assembling revealed eight nearly complete vessels and parts of 423 others from which restoration could be made. The ruin was excavated by Earl H. Morris for the American Museum of Natural History

➤ ABOUT 40 POTSHERDS from excavations at Sambayeque, Peru, appeared to belong to the same vessel. After a study of these and a number of broken vessels from the same site, a restoration was made in the American Museum of Natural History by Mr. Paul Richard, as shown at right.

The procedure was to place each sherd in its proper position according to shape and decoration. The sherds making contact at any point were fastened with "Duco." The empty spaces were filled in with plaster, which appears in the photograph as the lighter areas

A. M. N. H. Photo

sequence scheme for five types of pottery common to a large group of ruins in New Mexico. The consistent position of each pottery type in refuse heaps made the time sequence certain.

The effect of Nelson's paper can be easily imagined. It gave scientific archaeology in America a new birth. The younger archaeologists in the museums of the country were enthusiastic. What they saw was a new research tool, which if carefully used, could not fail. Ingenious guesses need not be regarded; let the potsherds speak for themselves. More and more field work would eventually solve the problem. Arizona and New Mexico soon became the main field for archaeological research; 20 years after Nelson's discovery of the basic scientific method an average of 40 archaeologists were making yearly excursions to that area.

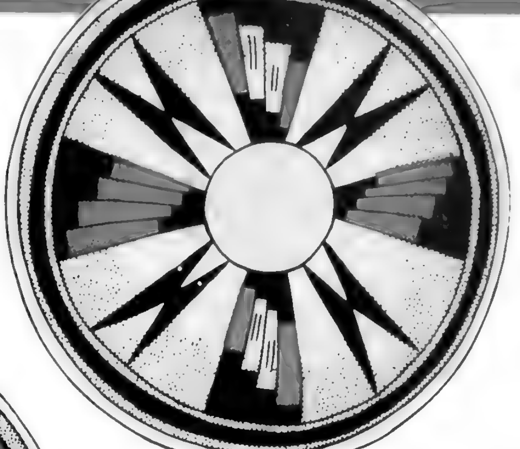
In 1914 the American Museum initiated the use of a supplementary method for dating ruins. Professor A. E. Douglass, University of Arizona, was using growth rings of the Big Trees of California and other large trees to date changes in the annual rainfall. When rainfall is abundant trees grow thick rings, in dry years, thin rings. Many of the ruins in Arizona and New Mexico contain large ceiling and floor beams, sections from the trunks of trees. It occurred to the writer that if these could be dated by Douglass, the ruins could be dated. Douglass thought he could do it, if sample cuttings from logs in ruins could be sent to him. Earl H. Morris, then a staff archaeologist for the American Museum, was requested to collect the samples. The method worked from the start. Today the actual cutting years are known for beams in several hundred different ruins. The oldest so far is a small structure near Flagstaff, Arizona, dated 217 A.D.

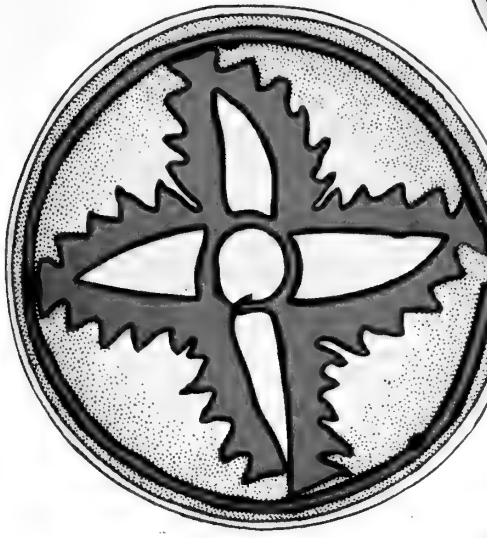
The tree-ring method did not antiquate the value of potsherds, because the timbers in many ruins have decayed. Further, once tree-ring dates are found for a type of pottery, they can be transferred to the records secured by excavation. Finally, where tree-ring dates were to be had, it was observed that the durations for many pottery styles ranged from 75 to 150 years. This in turn gave a check upon time estimates in places where no wood survived. So it is easy to understand why archaeologists pay so much attention to potsherds. They aptly speak of them as "the fossils of culture."

Five Culture Periods in the Pottery of New Mexico. N. C. Nelson

In this instance the key to chronology was discovered to lie in color and surface finish, not in shape or design.

→ Modern Ware. Black-on-pink and black-and-red-on-pink. 1680-1850





← Historic Two-color Glazed Ware. Brown or green on either gray, red, or yellow. 1450-1680

→ Three-color Glazed and Painted Ware. Black-glaze-and-red-paint on either gray, yellow, pink, or red. (?)-1450

← Two-color Glazed Ware. Black or brown on either red, yellow, or gray. Date not known

→ Two- and Three-color Painted Ware. Black on either white or red, and black-and-white on red. Date not known

Drawings by Worthington H. Southwick

Caves and Shell Heaps

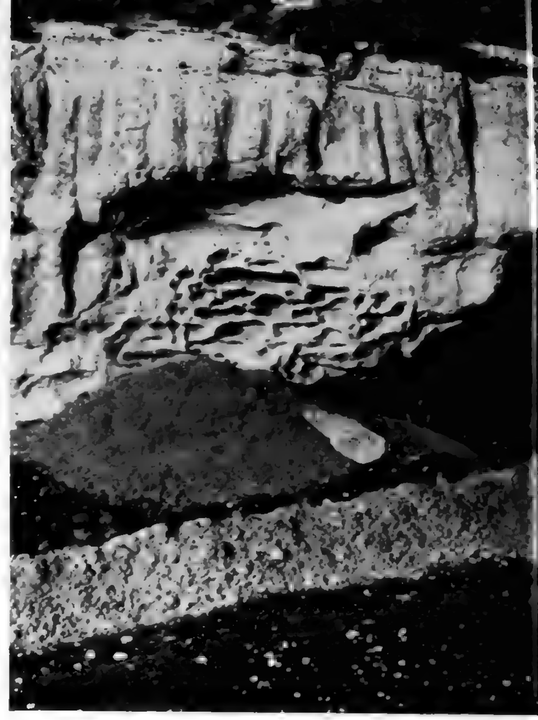
MOST people believe the first human beings were cave dwellers. This is more fanciful than true, but there is no denying that archaeology has learned a lot by the study of rock shelters and the entrances to caves, for the reason that such ready-made shelters were indestructible and so were occupied off and on by whatever people happened to be around. They were ideal defense positions against unfavorable weather as well as against animal and human enemies. Roomy rock and cave shelters were doubtless fought over time and again. Today archaeologists seek them because they contain precious beds of refuse, accumulated in orderly sequence and conserved, from which the past can be reconstructed.

Many of these shelters had such high ceilings that there was room to build up deep deposits of refuse. In Europe, for example, there are one or more cave shelters, the refuse in which reveals in time order all the main periods in the Old Stone Age, the New Stone Age, the Bronze Age, and the Iron Age. Rock and cave shelters are less conspicuous in America, but when found are highly prized by archaeologists. Several classic studies have been published by the American Museum, as for example Mammoth Cave, Kentucky, by Curator Nelson in 1915, and such caves as Cerro Sota and Fell's Cavern, Straits of Magellan, Chile, excavated in 1937 by Assistant Curator Junius Bird and his capable wife.

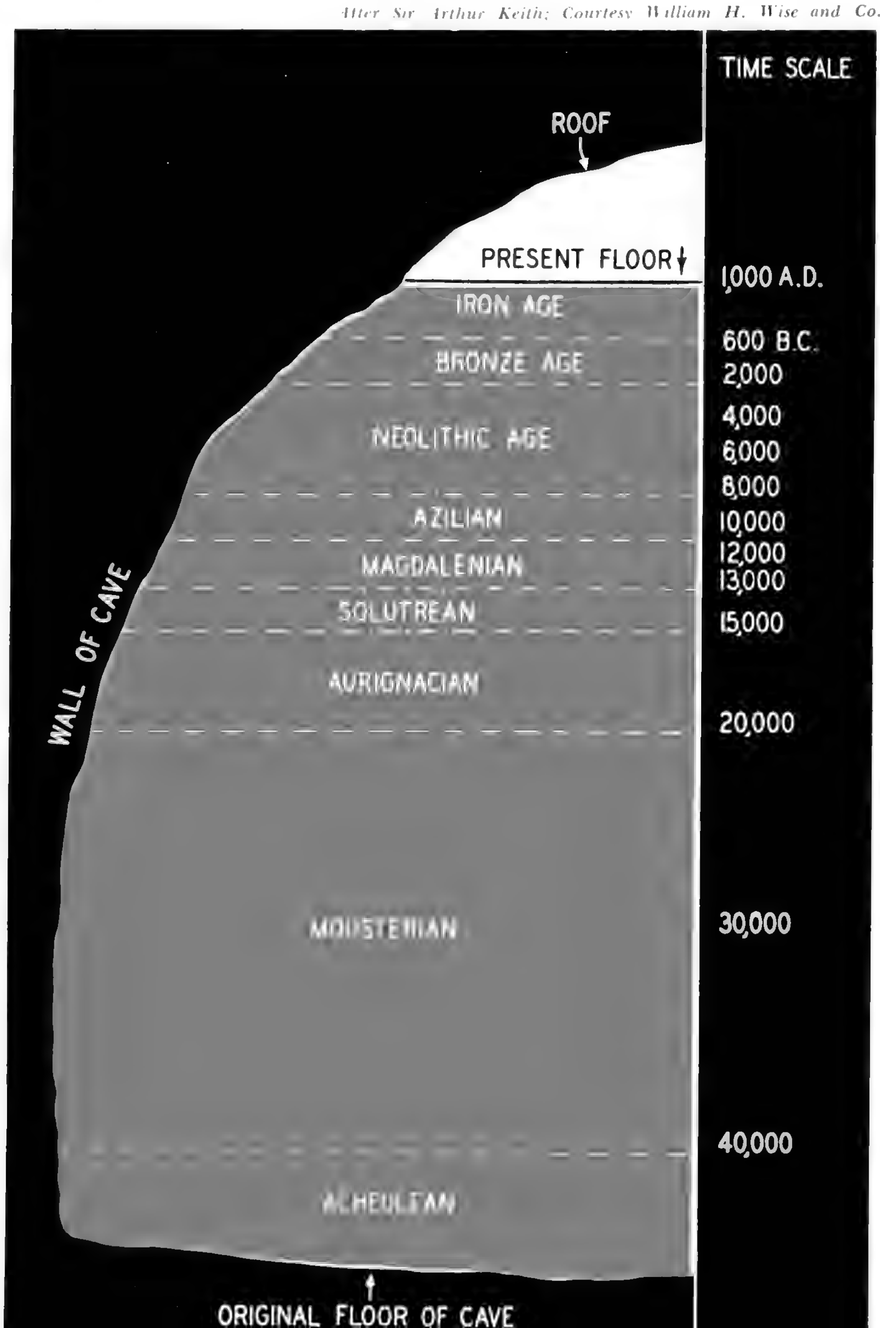
Yet if America does not lead the world in cave deposits, it does possess a grand series of shell heaps. These refuse heaps or kitchen middens line our coasts from Newfoundland southward, around the West Indies, down the east coast of South America to Cape Horn, thence up the Pacific side to Panama and on northward to the Arctic Circle and beyond. Shell heaps are not unknown inland. They are found, for example, along the Tennessee and the Ohio rivers, in fact, wherever edible fresh-water shellfish are abundant. Some shell heaps, or shell mounds, are of amazing size. The largest so far reported in the United States is about 30 feet high and covers 35 acres.

The reader need not be told how such shell mounds originate; they accumulate around the primitive cabins of shellfish eaters, together with bones, pottery, and discarded implements. As the level of refuse rises, new cabins will be built on the higher levels, and so on. Excavations in a large shell mound near Oak Hill, Florida, by Curator Nelson, showed that the Indians who started the mound did not make pottery, but eventually crude pottery does appear, which passes through several successive styles, culminating in ornate pottery.

It is expected that an archaeologist will save samples of the shells and bones for identification, to determine which of the animals are still living, which extinct. But for time sequences the chief dependence is upon the relative positions of the artifacts found in the refuse.

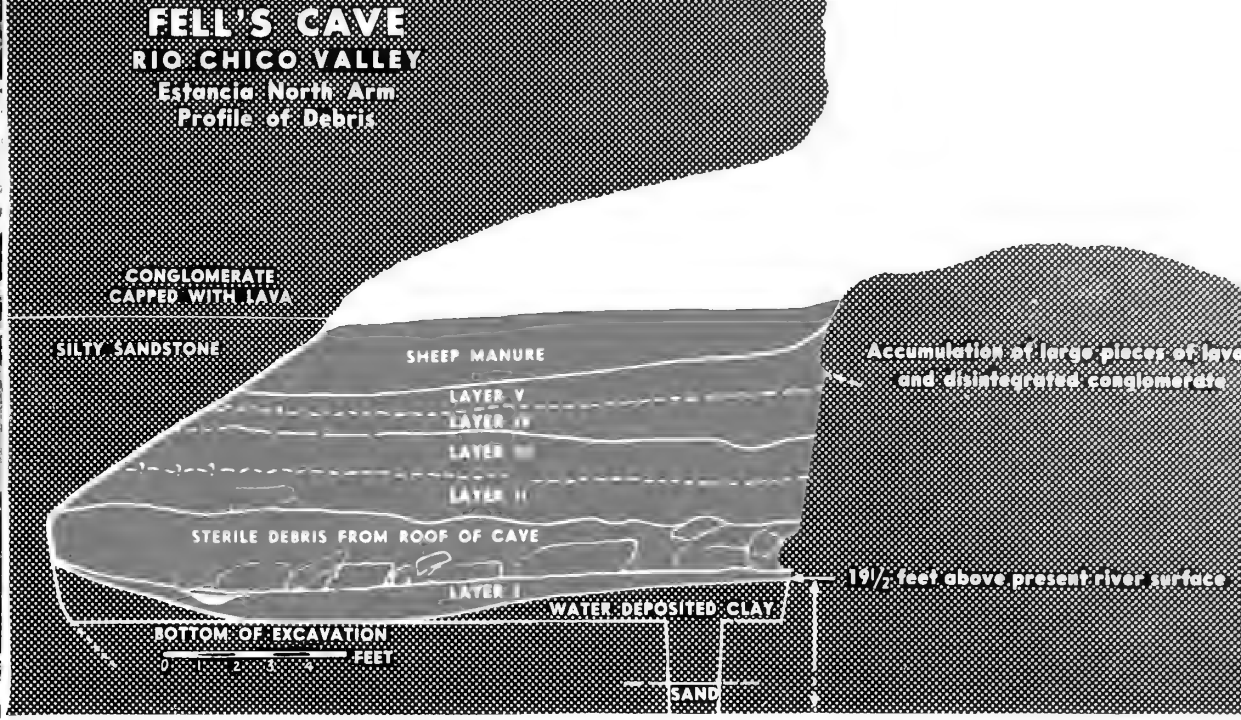


After Sir Arthur Keith; Courtesy William H. Wise and Co.



HAD EUROPEAN CAVE MAN lived in the same shelter for 50,000 years the debris would tell this story. Cultural changes are the archaeologist's key

A. M. N. H. Photo

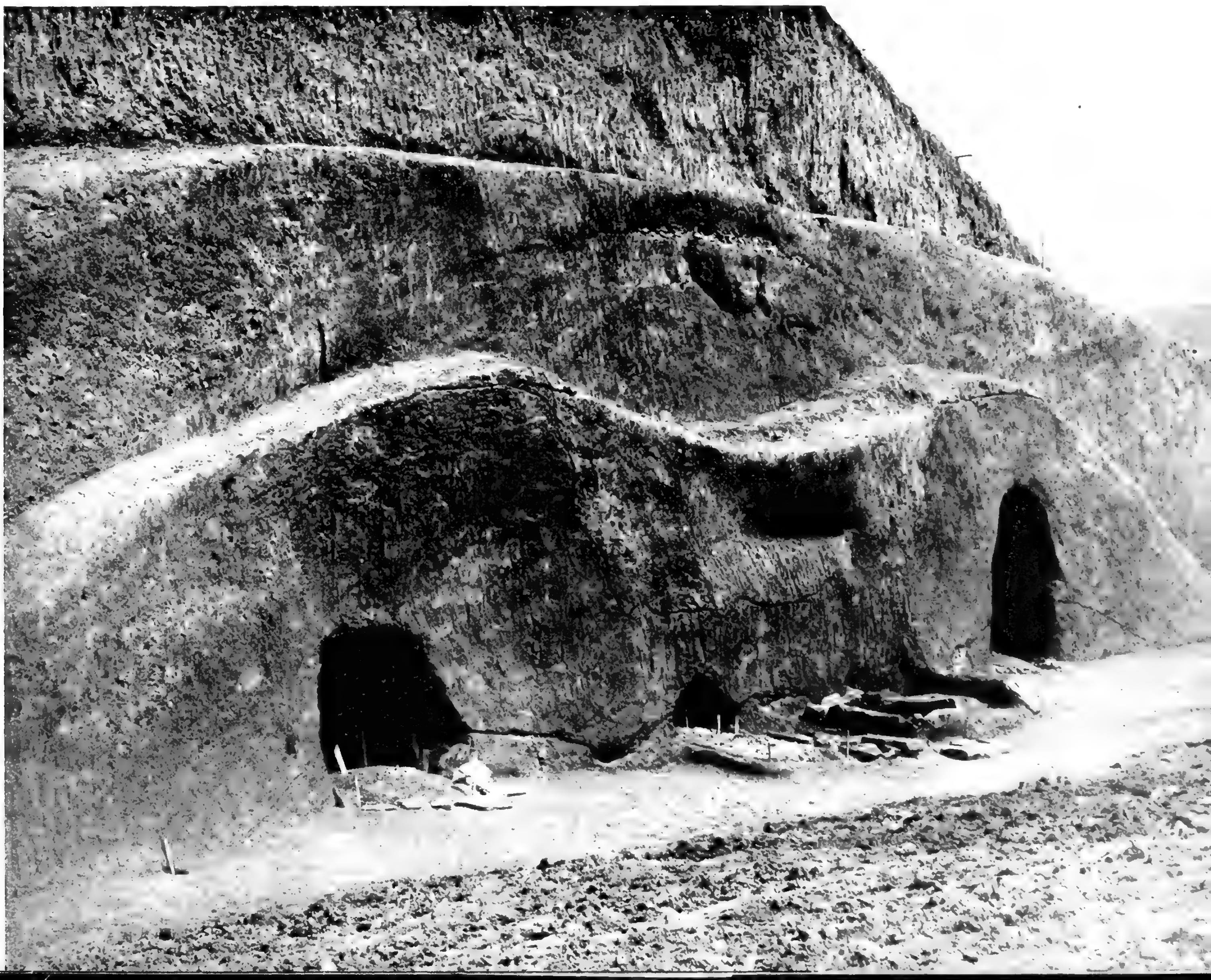


↑ A CAVE IN SOUTHERN CHILE excavated by Junius and Margaret Bird, American Museum of Natural History. In the last layer in this cave were found artifacts and human bones associated with the bones of extinct animals

↑ FIVE PRE-COLUMBIAN PERIODS of occupation revealed in a Chilean cave. In Layer I were bones of the extinct wild horse and the sloth, the first sure evidence that man lived in South America before these animals disappeared

↓ NOT A CAVE but a cross section of an Ohio mound under excavation. Several burials have been exposed by clearing of the mound floor. They were covered with log tombs, the decay of which caused a settling in the original fill

Ohio State Museum photo



Chicago University Field Station

▲ WORKING OUT A SKELETON is an exacting test of skill. Tiny trowels, awls of small sizes, fine brushes, and a hand bellows are the important tools. Shellac or other fixing solutions should be at hand

Why Burials Are Important

ARCHAEOLOGISTS are fond of digging up the prehistoric dead. People who do not like archaeologists often show their contempt by calling them "grave robbers." Two important kinds of information come from graves. The skeletons tell us much about the people who lived at the time and place, and the man-made objects in the burial give information as to their mode of life. If time sequences are known for some of these objects, a given skeleton can be dated relatively. The better preserved skeletons can be distinguished as male and female; even the age at death can be determined within an average error of five years. The most thoroughly excavated prehistoric cemetery in America was connected with the Pecos ruins in New Mexico. More than 1800 skeletons were excavated. The ages at death were determined for a large number, the details of which cannot be given here, but we note that while a few of these Pecos Indians lived longer than 80 years, only 20 out of every 100 reached the age of 55 years. In a modern white community 50 out of every hundred live to be 55 years of age or more.

The successful removal of a skeleton often calls for unusual skill and an inordinate expenditure of time and patience. In damp ground bones may be so soft as to defy movement until hardened by drying or by special treatment with fixing solutions. An inexperienced digger may tear away a skeleton without being aware of its presence. Since the teeth are less likely to take on the color of the damp soil, a bungling amateur may report that he found no bones, merely a few teeth.

Burial is an old, old custom. The most important invention is fire, but archaeology shows that burial is almost as old and that with it came the custom of placing tools, weapons, and food in the grave. It is usual to infer from this that the belief in a life after death is still older.

Digging in a Village

AS AN example of the right way to work in a village site we have selected excavations by the Rochester Museum, Rochester, New York, directed by Dr. William A. Ritchie. Three field photographs are reproduced by permission of the author. The site of a former prehistoric village was located near the town of Brewerton at the eastern end of Oneida Lake, New York State. Refuse and burials resulting from this village covered a flat about three acres in extent. Eight trenches were used in exploratory excavations, and two "test blocks" were carefully worked out. Some 1700 recognizable stone artifacts were uncovered. There was some pottery but it was all on or near the surface, so it is clear that the first generations to occupy the site did not make pottery. Further, they lived there long enough to make some changes in the kinds of stone implements they used.

The scientific objective

The reader may wonder why all this trouble. Doctor Ritchie has specialized in the prehistoric cultures of New York State. In the United States archaeologists identify cultures and classify them systematically. Doctor Ritchie saw in certain sites from the same part of the State what he suspected were traits of a new culture. Objects picked up from the surface made him hopeful that this site at Brewerton might qualify as a type for such a new culture. His excavations indicated that he was on the right track. In the high-sounding language of the profession, he named it the Robinson site, or component, in the Brewerton Focus, Laurentian Aspect, Northeastern Phase, Woodland Pattern. If you had any doubts as to archaeology being a science, this should silence you. Should you wish to know what all this means, you must consult the technical books on the subject; it is as intelligible to an archaeologist as (robin) *Turdus*, syn. *Merula migratorius* is supposed to be to an ornithologist. Doctor Ritchie's achievement is about equivalent not merely to the discovery of a new species but a new genus as well.

Incidentally your curiosity may be appeased by outlining the standard scheme of archaeological classification, as:

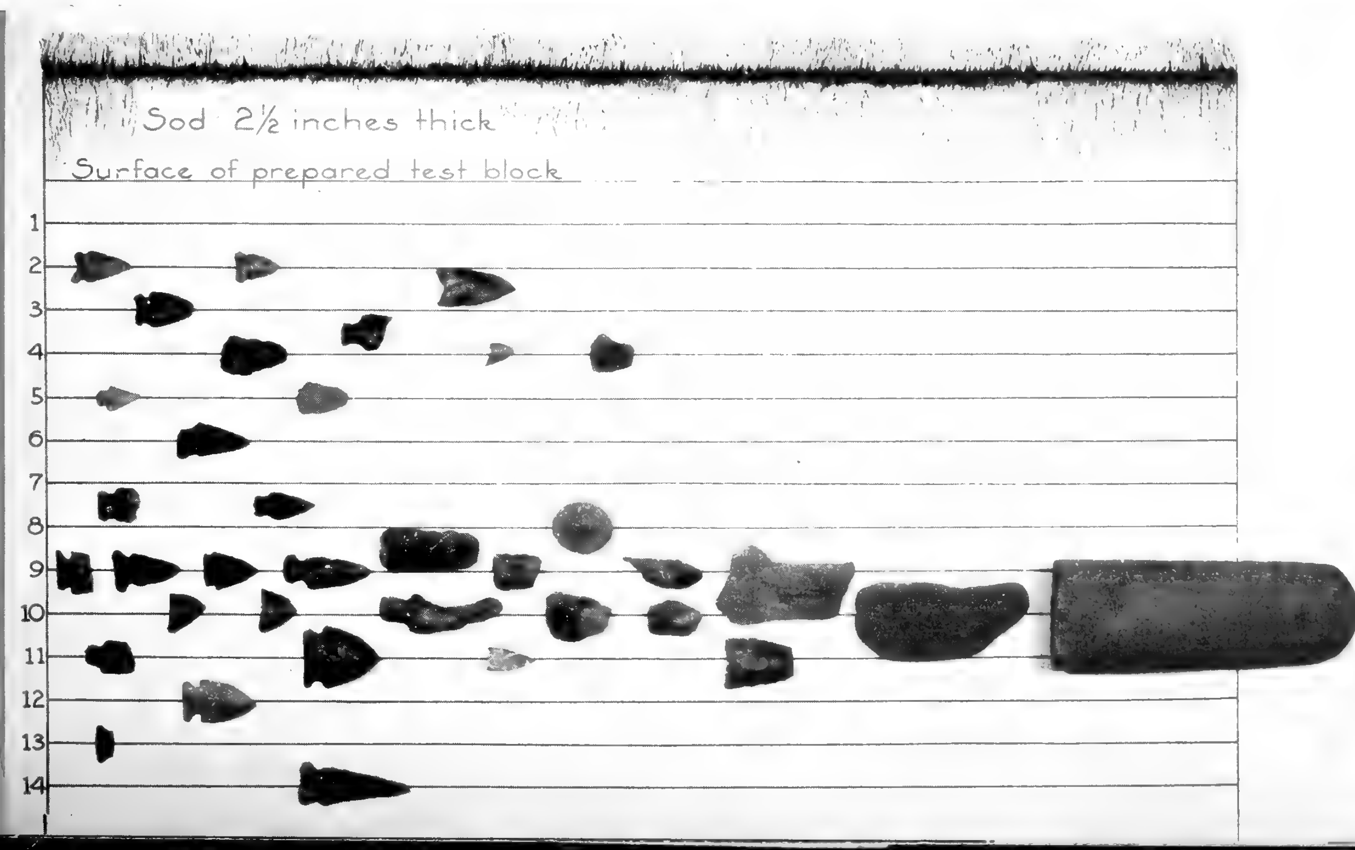
Component (Site): Associated complexes of artifacts found in a village site or in a camp site.
Focus: A group of components or sites which approach identity in their dominant types of artifacts.
Aspect: A group of foci with important similarities.
Phase: A group of aspects with fundamental similarities.
Pattern: A few artifact types, widely distributed, common to a large number of components.

(*Above, right*) Test block No. 1 has been cut around for careful excavation. The sod has been removed and stakes set to guide the excavators

→ Removing the earth in horizontal layers. Holes at the side mark storage pits beneath the village refuse

↓ When all artifacts were arranged in order, it was clear that most large projectile points lay below the ten-inch level, most small points above. Similar differences for other artifacts were noted, showing the general time sequence in culture during the period of occupation. Pottery occurred on the surface only

Photographs by courtesy of the Rochester Museum



Chicago University Field Station

Post Holes

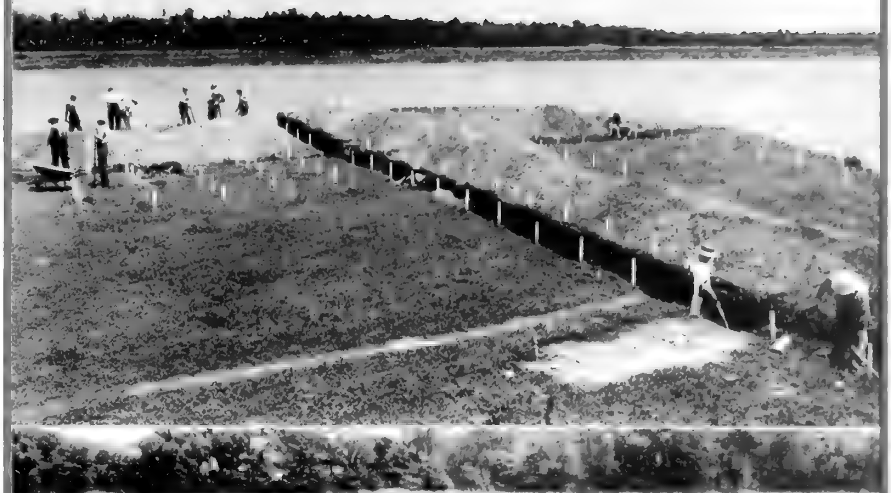
↑ Post holes reveal the layout of houses, defense palisades, scaffolds, etc. To overlook them when digging is inexcusable. With practice they are easily dissected out. In this instance there seem to have been two successive houses on the same site

↓ By slicing down below the original house floor the depth and direction of the post holes can be shown. The parallel lines have been marked according to the intersecting lines on a plan of the site, for ease in reading the photograph

Major W. S. Webb

Stakes

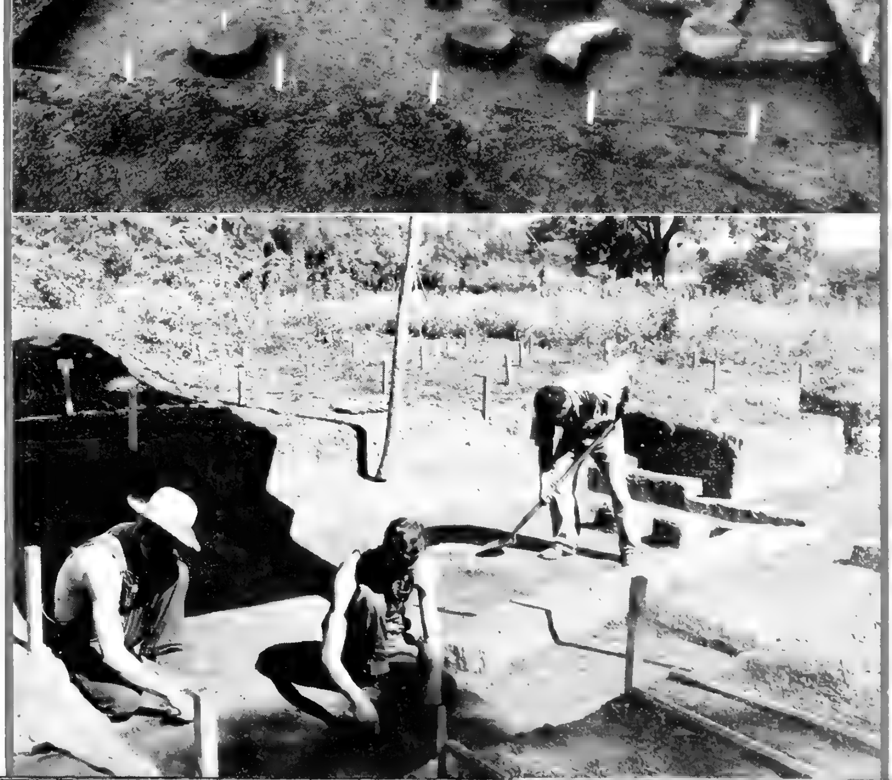
→ The positions of all objects uncovered are plotted on the base map in relation to stakes previously driven into the ground. Exploration of a burial ground begins with the digging of trial trenches, usually at right angles, as at right. Test blocks are then selected for thorough excavation. In this instance the burials were in a part of the accumulated village refuse, probably because graves were easily dug therein



→ The trench at this stage shows burials partly worked out. A careful record will be kept as the material is removed and studied. This is the same site as above on Seven Mile Island, Tennessee River, worked under the T. V. A. Archaeological Project by Major W. S. Webb, Director, 1936-38

→ In the refuse of this village site there were many pits. The archaeologists cut around these so as to leave the original blocks for dissection and study. Some pits were lined with clay but were found filled with loam containing a few artifacts of stone, copper, and galena. This is at Pickwick Basin, Tennessee; Major W. S. Webb, Director

→ Village sites are explored by removing the debris down to the original hard surface of the ground. The material is carefully peeled off in thin horizontal layers. For the most part small trowels are used. (Chicago University Field Station)



1 Archaeologists must be patient, industrious, and resourceful. Major W. S. Webb's trenches and camp were flooded one night. Records were damaged and equipment lost, causing delay and extra work. (Tennessee River T. V. A. Project)

2 Mrs. Junius Bird on shift at Palli Aike cave in Chile. Dry caves preserve perishable materials, but the fine powdered dust rises with every step, and masks must be worn. As the debris is removed it should be screened to save tiny objects

3 Mr. and Mrs. Bird found peace-time gasoline shortages in southern Chile an aggravation. The expedition Ford responded to both wind and man power, but ultimately a yoke of plodding, time-consuming oxen was found the best solution

1

➤ Archaeology can recover lost history. Jamestown, Virginia, was settled in 1607, but the town was destroyed in 1698. Recent excavations by an archaeologist have given new information. Foundations of forgotten houses with cellars filled with debris were uncovered. The streets of the old town were traced. (Archaeologist, Jean C. Harrington, National Park Service)

➤ Thousands of potsherds and objects of glass, iron, and stone were uncovered. These were cleaned and repaired in the laboratory at Jamestown. Most of the objects were brought from England between 1607 and 1698, so this dates them, even though their history in England has been lost

A. M. N. H. Photo

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A. M. N. H. Photo

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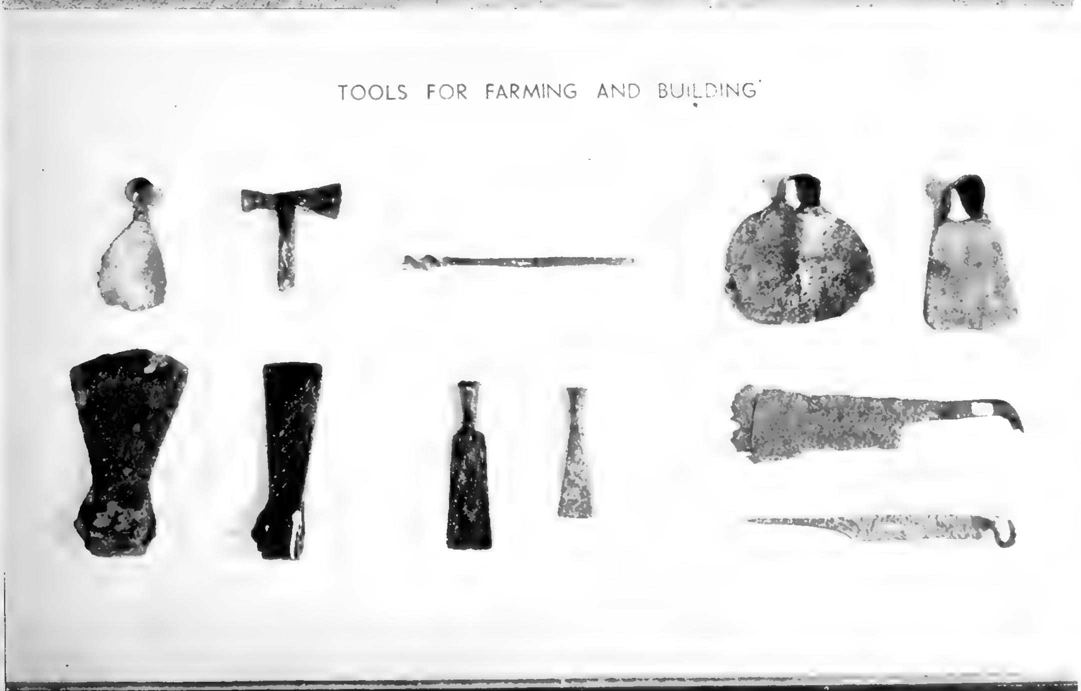


← TYPICAL OBJECTS from excavations at the site of Jamestown. The number and variety of glass wine and rum bottles is impressive. Household pottery is abundant. Clay tobacco pipes of many styles were found. Some fine decorated tiles probably came from Holland

EQUALLY INTERESTING are the objects of iron and steel (*at bottom*). The National Park Service has used archaeological methods in St. Augustine, Florida, Roanoke Island, North Carolina, and many other historic sites. In Canada archaeologists have found the correct locations for a number of old fur trading posts. Recently archaeologists from Harvard began excavations in Plymouth, Massachusetts. Obviously the future will see our own history greatly enriched by archaeological research

National Park Service Photos

Step By Step

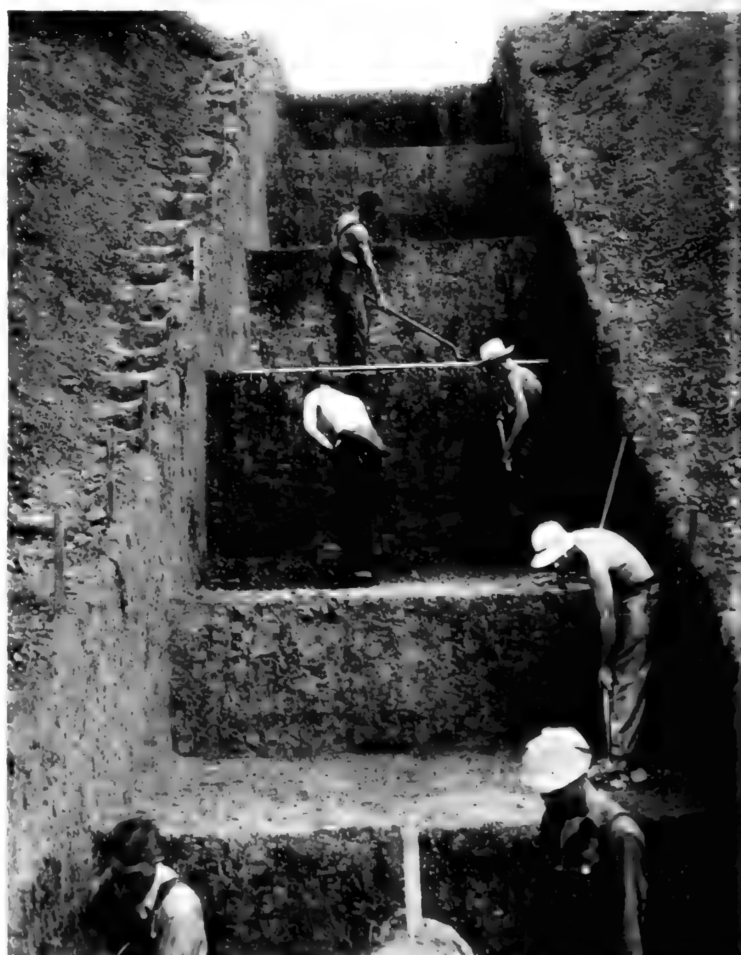
1 PLANNING THE PROJECT: the Director of Excavations and graduate students in conference, Chicago University Field Station. After a careful examination of a site a detailed plan for its excavation must be made. A temporary building may be erected as a field laboratory, where drawings can be made, notes and photographs filed, conferences held, etc.

Major W. S. Webb

2 A VIEW OF THE SITE: two mounds before excavation. If a mound has not been cultivated or otherwise greatly disturbed, it will be covered by trees and underbrush. This coverage must be cleared away before excavations begin

5 ↓ EXCAVATION UNDER WAY: a view showing a cross section of a mound. The blocks of earth contain burials to be worked out later. The base of the mound is shown in the foreground

Major W. S. Webb



6 ► AN ALTERNATIVE METHOD: step-trenching a mound instead of beginning at the base. The planes defined in the survey plan must be followed to record objects found. Note the stakes

Chicago University photo

Chicago University Field Station

3 THE SURVEY. Before digging, a survey must be made to establish the horizontal and vertical planes needed to record the positions of all objects found. Meanwhile, clearing of the surface may be under way

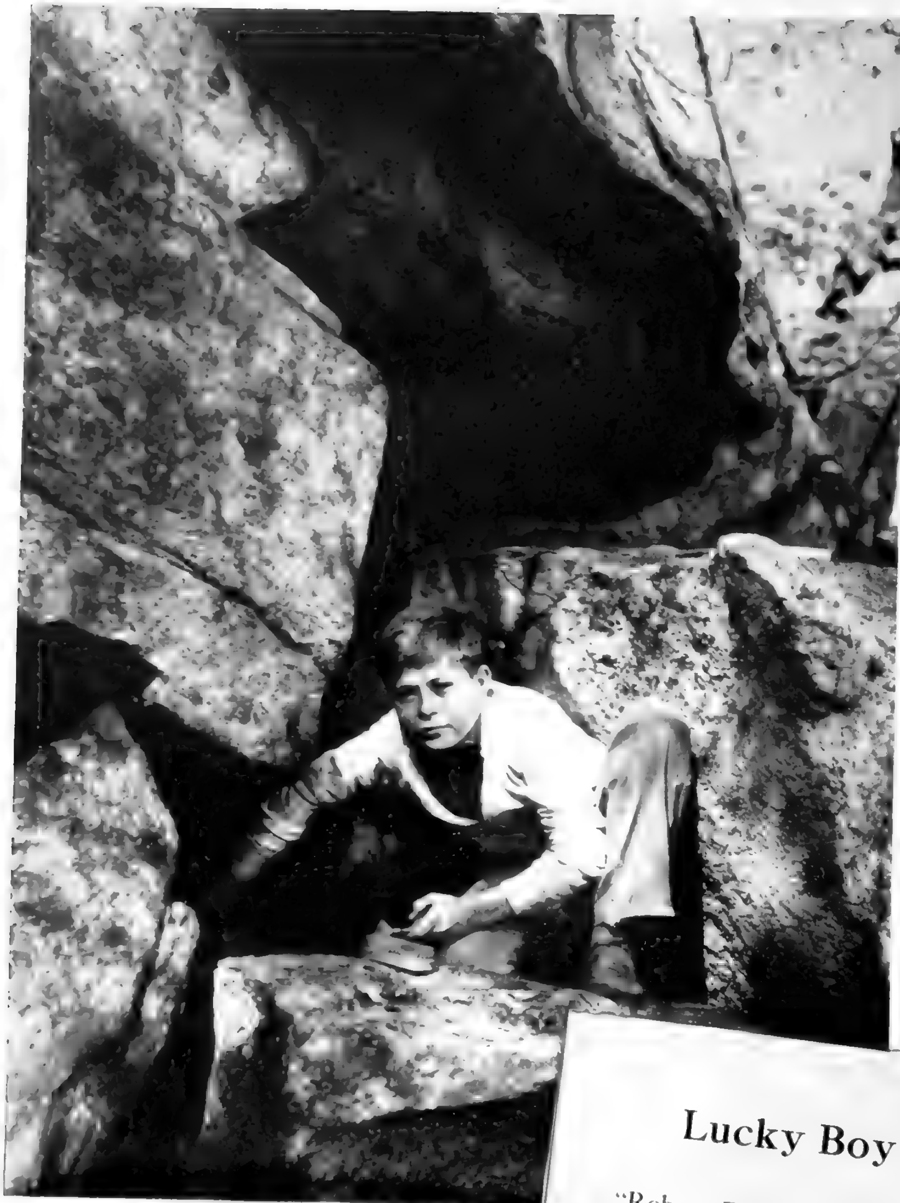
Major W. S. Webb

4 THE BASE PLAN of the mound is divided into squares marked by vertical stakes. These are driven down as excavation proceeds. Usually each stake is numbered to assist in recording the objects found

7 THE MOUND CLEARED AWAY. The original floor of the mound usually approximates the basal horizontal plane. The stakes, now at a much lower level, are still in their original relative positions

Chicago University Field Station photos

8 CLEANING THE SPECIMENS: students of archaeology washing potsherds before assembling them in their original order as excavated for determining time sequences



Trailside Museum photo

← MASTER SCOTT finds door to a hidden cave

What to Do When You Discover A New Site

IN SOME of the pictures you may note post holes which have been cleaned out to show the positions and sizes of the posts originally standing there. These holes tell us something about the buildings once occupying the site. Even a piece of matting may leave an imprint in the earth which can be worked out to reveal the weaving technique. H. C. Shetrone, Ohio's leading mound expert, is able to trace out the individual loads of earth dumped down by the carriers in building the mound, even finding the imprint of a basket which one of them failed to empty. Not all archaeologists are so skilful, but many of them are. It is clear that an ignorant careless digger would not only fail to see these important things but would destroy all traces of them.

The archaeologist is pleased when so many people take an interest in his subject, but he cannot be happy over their enthusiasm to dig things out, because he knows too well how blind they will be to what should be recorded. We hope the reader has acquired some idea of the responsibility he assumes when he digs into a rock shelter or a prehistoric grave.

We have but space enough to mention how a boy, Robert D. Scott of Fort Montgomery, New York, noticed a small hole in the face of a cliff. Entering, he found himself in a small cave, upon the floor of which he saw bits of pottery. He reported his find to the archaeologist in the Trailside Museum at Bear Mountain. Young Scott was rewarded by assisting in the excavations, was heralded in the press as "the luckiest boy in the United States," and duly praised for his good sense in not trying to dig out the "relics" secretly. The *New York Times* made his achievement the subject of an editorial (May 11, 1941), reprinted below:

Lucky Boy

"Robert D. Scott is 13 years old and in the seventh grade of the Fort Montgomery grammar school. At this moment he is the luckiest boy in the United States, having just done what every normal boy in the United States wants to do. He found a hidden cave with a treasure inside. Nobody had been in that cave for unknown hundreds of years. Robert wormed his way through a boy-sized hole, which had been left when an ancient earthquake closed the entrance. Inside he found Indian pottery, arrowheads, medallions of slate once worn around Indian necks, and an old pipe of red clay.

"It seems a shame to reveal the location of Robert's cave, but its picture has already been in the papers. It is not far from the Bear Mountain bridge. Archaeologist James D. Burggraf of the Trailside Museum believes that it was used by Algonquin fishermen before the time of Columbus. To an archaeologist it is tremendously exciting to get evidence that the Algonquins were in this part of the Hudson Valley before the Iroquois pushed in and established a kind of corridor between the two great sections of the Algonquin race. The Iroquois, in short, weren't old settlers at all. They happened along after the pioneering was finished.

"Robert would be richer if he had found a couple of kegs of pieces of eight. But Indians are more fun. They teach a useful lesson, too. Robert can tell his elders with some assurance that ten or twenty years of big noises in Europe or China aren't all there is in the history of the human race. If we have to go back to living in caves it won't be the first time. We can stand it."

From the New York Times

Additional Information on Archaeological Methods

THE following publications have been selected to give more detailed information as to the techniques of archaeological excavation and the interpretation of the data. Some of them contain instructive photographic reproductions of trench-sections, artifacts, and diagrams of stratigraphy.

Antiquity and Migrations of the Early Inhabitants of Patagonia. By Junius Bird. The Geographical Review, Vol. 28, No. 2. 1938

The Discovery of Man. By Stanley Casson. New York. 1939

Man Makes Himself. By Gordon V. Childe. London. 1936

Rediscovering Illinois. By Fay Cooper Cole and Thorne Duell. Chicago. 1937

The Su Site, (New Mexico). By Paul S. Martin. Field Museum of Natural History, Chicago. Vol. 32, No. 2. 1943

Digging in the Southwest. By Ann Axtell Morris. New York. 1933

Digging in Yucatan. By Ann Axtell Morris. New York. 1931

The Aztec Ruin, (New Mexico). By Earl H. Morris. Anthropological Papers, American Museum of Natural History. New York. Vol. 26, Part 1

Chronology of the Tano Ruins, New Mexico. By N. C. Nelson. American Anthropologist N. S. Vol. 18, 1916, pp. 159-180

Contributions to the Archaeology of Mammoth Cave and Vicinity, Kentucky. By N. C. Nelson. Anthropological Papers, American Museum of Natural History, New York. Vol. 22, Part 1. 1917

Chronology in Florida. By N. C. Nelson. Anthropological Papers, American Museum of Natural History, New York. Vol. 22, Part 2. 1918

Two Prehistoric Village Sites at Brewerton, New York. By William A. Ritchie. Research Records of the Rochester Museum of Arts and Sciences, No. 5, Rochester, N. Y. 1940

The Mound Builders. By Henry Clyde Shetrone. New York. 1930

An Archaeological Survey of the Norris Basin in Eastern Tennessee. By William S. Webb. Bureau of American Ethnology, Bulletin No. 118. Washington, D. C. 1938

An Archaeological Survey of Pickwick Basin in the Adjacent Portions of the States of Alabama, Mississippi and Tennessee. By William S. Webb and David L. DeJarnette. Bureau of American Ethnology, Bulletin No. 129. Washington, D. C. 1942

OTHER PUBLICATIONS on Archaeology

Order any of these items through Man and Nature Publications, the American Museum of Natural History, Central Park West at 79th St., New York City, N. Y. They are all published by the Museum

ANCIENT CIVILIZATIONS OF MEXICO AND CENTRAL AMERICA. By HERBERT J. SPINDEN, Ph.D. *Third and revised edition, 1928. 270 pages, 48 plates, 86 text figures, map and diagram. Handbook No. 3. Cloth, $1.00; postage, 7 cents.*

This book is intended as a general commentary and explanation of the more important phases of the ancient life and history of the Indians of Mexico and Central America, popularly considered as Aztecs but actually including a number of distinct though related races, notably the Maya.

OLD CIVILIZATIONS OF INCA LAND. By CHARLES W. MEAD. *Second edition, 1932. 141 pages, many illustrations and a map. Handbook No. 11. Cloth, $1.00; postage, 7 cents.*

A book describing the arts and industries of the highly civilized Incas of South America, their marvelous textiles and extraordinary skill in stone work.

MASTERPIECES OF PRIMITIVE SCULPTURE. By GEORGE C. VAILLANT, Ph.D. *1939. 11 pages, 23 illustrations. Science Guide No. 99. Price, 25 cents; postage, 3 cents.*

An excellent presentation of the sculpture of the primitive peoples of the world, profusely illustrated by striking examples from the collections of the American Museum. This leaflet is adapted for use by students of archaeology and artists interested in primitive sculpture.

THE HALL OF THE AGE OF MAN. By HENRY FAIRFIELD OSBORN, Ph.D. *Seventh edition revised to 1938 by William K. Gregory and George Pinkley. 54 pages, numerous illustrations. Science Guide No. 52. Price, 50 cents; postage, 3 cents.*

This describes the exhibits in the American Museum illustrating what is known of the origin, relationships, and early history of man as deduced from his remains and implements. It also shows the paintings by Charles R. Knight depicting the animals by which man was surrounded in the early stages of his existence.

POTTERY OF THE SOUTHWESTERN INDIANS. By PLINY EARLE GODDARD, Ph.D., *1931. 30 pages, 22 illustrations. Science Guide No. 73. Price, 30 cents; postage, 3 cents.*

A description of the methods of making pottery, as well as the sequence of types.

SOUTH AFRICAN ROCK PICTURES. By N. C. NELSON. *1938. 12 pages, 12 illustrations. Science Guide No. 93. Price, 30 cents; postage, 3 cents.*

A description and discussion of the primitive pictorial art exemplified by the rock pictures recently discovered in South Africa, including facsimile illustrations of various typical examples.

PERUVIAN ART. By CHARLES W. MEAD. *Fifth edition, 1929. 24 pages, 9 full-page plates. Science Guide No. 46. Price, 10 cents; postage, 3 cents.*

Showing how the strange designs of the ancient Peruvians on textiles and pottery are really representations of birds, beasts, and fishes. A help for students of design.

ARTISTS AND CRAFTSMEN IN ANCIENT CENTRAL AMERICA. By GEORGE C. VAILLANT, Ph.D. *1935. 102 pages, numerous illustrations. Science Guide No. 88. Price, 70 cents; postage, 3 cents.*

This provides examples of the extraordinary range of Central American art and gives a general picture of Pre-Columbian sculpture and architecture.

THE HISTORY OF THE VALLEY OF MEXICO. By GEORGE C. VAILLANT, Ph.D. *1940. Science Guide No. 103. Price, 10 cents; postage, 3 cents.*

A folded chart, serving as a supplement to *Artists and Craftsmen in Ancient Central America* (above) : a graphic presentation showing the successive stages of Mexican art from 100 B.C. to 700 A.D.

Insect Control
IN THE
Victory Garden

By C. H. CURRAN

ASSOCIATE CURATOR OF INSECTS AND SPIDERS

SCIENCE GUIDE No. 117 — THE AMERICAN MUSEUM OF NATURAL HISTORY

ACKNOWLEDGMENT

The illustrations in this booklet (with the exception of those of the Japanese beetle and Mexican bean beetle) have been furnished by the Division of Entomology, Science Service, Department of Agriculture, Canada. We greatly appreciate the generous co-operation of the Dominion Entomologist in giving permission to use the illustrations and in furnishing prints.

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COMMITTEE ON POPULAR PUBLICATIONS

Insect Control

IN THE

Victory Garden

By

C. H. CURRAN, D.Sc., B.S. Agric.

SCIENCE GUIDE No. 117

THE AMERICAN MUSEUM OF NATURAL HISTORY

1943

The Healthy Garden

The victory gardener, whether amateur or seasoned veteran, is certain to be worried by insect pests. Some of these are capable of causing serious losses, but it is comforting to know that, with regular examination of plants and the use of simple control methods, the ordinary small garden will come through the season with little or no loss. The victory gardener has a big advantage over the commercial grower because he can keep a keen watch on almost every individual plant. Hand picking of most pests is all that will be necessary. There are only a few kinds of garden insects that will require chemical treatment, and this does not call for extensive equipment or a large variety of insecticides.

Before discussing the various insects and insecticides, we may consider the value of certain cultural practices in controlling some kinds of insects, and the effect of environment on the garden and on the insect problem in general. The position of the garden in relation to other gardens is important, because if gardens are contiguous and the same crops are grown in all, the danger of insect damage is much greater. At the same time, control measures may be more economically carried out if a number of gardeners cooperate in buying equipment and in mixing insecticides for all the gardens at one time.

It is generally agreed that clean culture reduces insect damage. However, the small gardener cannot always practice clean culture. Adjacent yards may contain numerous weeds and debris, and insects may flourish in these. To cut the weeds after they have grown does not help the isolated gardener; it makes matters worse, because some kinds of insects infesting the weeds will migrate to garden plants.

Gardens adjacent to waste land and weed patches are very frequently subject to damage by cutworms and other migratory caterpillars. In order to guard against these it is frequently advisable to carry out cutworm control before setting out garden plants.

The general cleanup of adjacent waste land should occur in the fall in order to remove overwintering protection for insects, or in the very early spring. Late spring or summer cleanup will cause tarnished plant bugs and other pests to move to the garden. It is often better to leave lush growing weed patches alone at this time, because the pests will find plenty of food there.

No attempt has been made to include all the insects found in the vegetable garden, and some crops that are not suitable to the victory garden are not mentioned. The more common pests are discussed and control measures given for these. Other insects with similar habits may be controlled by the same treatment.

Insecticides

Two types of insecticides are used in insect control—stomach poisons for chewing insects and contact poisons for sucking insects.

Stomach Poisons

Stomach poisons are used in the control of chewing insects. They may be applied either as a spray or a dust, but the average victory gardener will find spraying more satisfactory and less expensive.

Arsenate of Lead

This is the best known of the arsenical poisons. It is a white powder and is used at the rate of 1 to 2 pounds to 50 gallons of water. It is a rather slow killer but is safe to use because it does not burn the foliage. To prepare dust, mix 1 pound of powder with 6 to 8 pounds of hydrated lime or 9 pounds of dusting sulphur.

Arsenate of Lime

This is a fine white powder with fast killing properties but apt to burn the foliage. It is used at the rate of ¾ pound to 50 gallons of water, 2 pounds of hydrated lime being added to prevent burning. It does not adhere as well as arsenate of lead but is the cheapest of the arsenicals. For dusting, mix 1 pound with 10 pounds of hydrated lime.

Paris Green

This is the oldest of the arsenical insecticides and is still used for the potato beetle and in poison baits. Other arsenicals are as good for potato beetles. With half a pound of Paris green in 50 gallons of water, add 2 or 3 pounds of hydrated lime to prevent burning. For dusting, mix one pound of Paris green with 20 pounds of hydrated lime.

Magnesium Arsenate

This is a white powder, chiefly used in the control of Mexican bean beetles. It is mixed at the rate of 1 pound to 50 gallons of water. When used as a dust, 1 pound of the powder is mixed with 10 pounds of hydrated lime.

Sodium Fluosilicate

Normally a white powder, this chemical contains a green dye when used for household insects. It is used in the control of the Mexican bean beetle. Mix about 1½ pounds per 50 gallons of water. As a dust, dilute at the rate of 1 pound to 8 or 9 pounds of hydrated lime.

These are used in the control of sucking insects and kill by direct contact.

Nicotine Sulphate

This is the most commonly used contact insecticide and it is the one that will be chiefly used during the war. The standard for nicotine sulphate is 40% nicotine, and dilutions are based on this content. Six ounces make 50 gallons of spray. The addition of 2 pounds of soap to this amount increases the efficiency of the spray. For use as a dust, mix 5 pounds with 100 pounds of hydrated lime.

Pyrethrum and Rotenone

Rotenone is not available at the present time, but a limited amount of pyrethrum is available in packages of 1 pound or less. This powder is applied as a dust. It is used chiefly for the control of the cabbage butterfly and the Mexican bean beetle and must be applied every 10 days to 2 weeks to be effective.

Soap

Soap has been pretty generally replaced as an insecticide by the other contact sprays, but it can be used in the control of aphids. Three pounds of laundry soap will make 5 gallons of spray. The soap is cut into thin strips and dissolved in hot water. The solution is then diluted to the final amount.

The chief use of soap is as a spreader in sprays, and it is then used at the rate of 2 pounds dissolved in a small amount of water to 50 gallons of spray.

Nicotine Spray

The smoker of cigars and cigarettes may make a spray that will prove satisfactory in the small garden. Cigar and cigarette butts may be saved, thrown into a bucket of water, and allowed to soak. In order to determine whether the liquid is strong enough, it can be tested on aphids, of which there are certain to be many in or near the garden. It is advisable to remove the charred ends of the cigarettes, otherwise the liquid will be very dark and the odor unpleasant. The liquid may be strained through a cloth in order to remove particles that would clog the sprayer.

Tobacco Dust

This usually comes diluted and ready to apply. It is useful for aphids and flea beetles and also serves to some extent as a soil insecticide.

Bordeaux Mixture

This is a combination of bluestone (copper sulphate) and lime. It is prepared by dissolving 3 pounds of bluestone in water, mixing 3 pounds of hydrated lime separately in water, and combining the two. This is diluted to 50 gallons. When using the commercial dust to make a spray, follow the table on page 6. If Bordeaux powder is to be made at home, finely

AMOUNTS

Amounts of concentrated insecticides to produce convenient amounts of spray or dust

SPRAYS	For a small garden, mix any of these with 1 gal. of water	For a medium size garden, mix any of these with 6 gals. of water	For a large garden, mix any of these with 25 gals. of water
Arsenate of lead	3 teasp.	2 oz.	8 oz.
Arsenate of lime	2½ teasp.	1 oz.	6 oz.
Hydrated lime	2½ teasp.	1 oz.	6 oz.
Paris green	1½ teasp.	¾ oz.	4 oz.
Hydrated lime	1 oz.	4 oz.	1 lb.
Nicotine sulphate (40% Nicotine)	1½ teasp.	8 teasp.	4 oz.
Soap	1 oz.	4 oz.	1 lb.
Bordeaux mixture powder	2¾ oz.	1 lb.	4 lbs.

DUSTS	For a small garden, mix any of these with 5 lbs. of hydrated lime	For a medium size garden, mix any of these with 10 lbs. of hydrated lime	For a large garden, mix any of these with 50 lbs. of hydrated lime
Arsenate of lead	10 oz.	1¼ lbs.	6¼ lbs.
Arsenate of lime	7¼ oz.	14½ oz.	4½ lbs.
Paris green	5 oz.	10 oz.	3⅛ lbs.
Nicotine dust (For a 3% mixture)	6 oz.	12 ozs.	3¾ lbs.
Nicotine dust (For a 5% mixture)	9½ oz.	1¼ lbs.	6½ lbs.

ground bluestone must be used. The dust contains 1 part of bluestone to 8 to 10 parts of hydrated lime.

Corrosive Sublimate

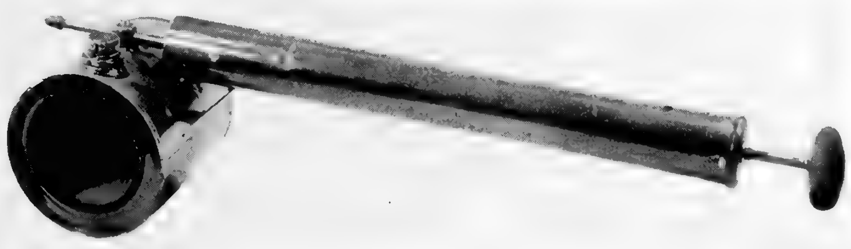
This is a special insecticide used in the control of root maggots. It is a heavy white powder, which is dissolved in water at the rate of 1 ounce to 12 gallons. It is extremely poisonous and must be handled with care, but, as used in the vegetable garden, it is perfectly safe.

The solution destroys metal containers, so the powder must be dissolved in a wooden, glass, or earthenware container. A stock solution may be made by dissolving an ounce of powder in warm water and diluting to 1 gallon. This stock may be stored in quart jars, 1 quart being added to 3 or 4 gallons of water when ready to apply.

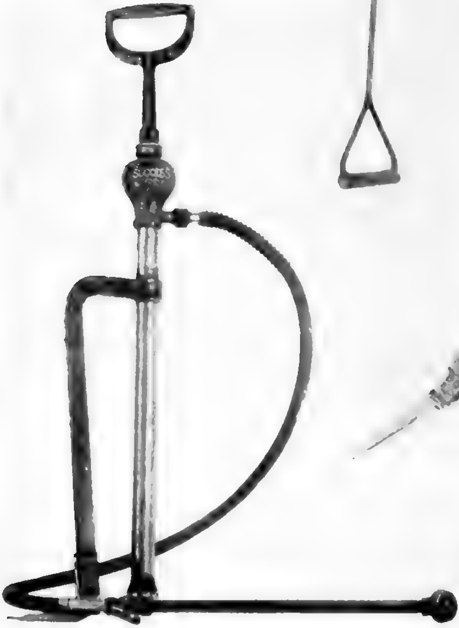
Danger of Arsenical Poisoning

Many people fear being poisoned as a result of eating vegetables that have been sprayed by poisonous substances, particularly arsenicals. Although arsenicals have been used for spraying for about 75 years, it was only after the last war that attention was focused on arsenical poisoning. This came about through the British Government's limiting the amount of lead arsenate residue to be allowed on imported apples. The British were not so much concerned about the arsenic as about the lead, which remains in the body and may cause lead poisoning.

It is perfectly safe to use arsenicals on all vegetables, and their use is recommended by the Canadian Government. If applied according to directions and if the vegetables are well washed before cooking, there is absolutely no danger of poisoning. As an added precaution, do not use the cooking water from plants recently sprayed with arsenicals for making soup. To escape any possible danger of lead poisoning, use calcium arsenate.

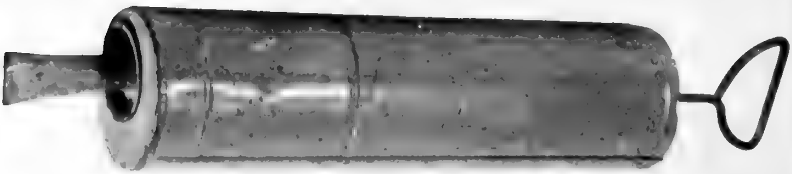


Small type hand sprayer



Above, 5-gallon knapsack sprayer

Left, stirrup pump bucket sprayer



Small type of hand duster

Applying the Insecticides

Spraying

To protect plants properly, spraying must be thorough, and the beginner may have difficulty in determining this. If spray drops from about one-fourth of the leaves, and almost all show signs of spray dots above, and it is felt that most of the leaves have been sprayed below, then the job is satisfactory. The novice is likely to use more spray than necessary, but it is better to use too much than not enough. Only experience will provide a proper balance. When plants are small, the garden may need only a quart of spray, but when they become large several gallons may be required.

Some insects feed on the under side of the leaves, and some on the upper side, while others may chew the whole leaf. A good policy in spraying is to spray the under sides of the leaves to such an extent that the drifting spray will be sufficiently heavy to allow about 50% of the upper surface to glisten. Begin on one side of the row at one end and work backward until that side is finished. Repeat on the other side, also taking in that side of the next row. When treating the lower leaves of beans, cabbages, and other low-growing plants, keep the spray gun well away from the plants and as close to the ground as possible. If you have a sprayer with an up-turned nozzle the task will be greatly simplified.

In using contact sprays, the task is often simplified. Some of the insects to be killed feed on fully exposed surfaces of the plants, so it is possible to hit them with a direct spray from several angles. However, some insects curl the leaves of the plants, and unless the culprit is actually hit the spraying will be ineffective. Contact sprays must be much more thoroughly applied than stomach poisons if satisfactory results are to be obtained.

Spraying Equipment

The spraying equipment will depend upon the size of the garden or gardens it is to cover. It must be remembered that only certain of the vegetables will need spraying. In the average garden of less than 10,000 square feet no special spraying equipment is necessary, providing the gardener has a good spray gun. If the garden is not more than 2,000 or 3,000 square feet the ordinary, small household "flit" gun will prove ample. In larger gardens a large "flit"-type gun will do the work. In gardens of over 10,000 square feet one of the small knapsack spraying machines of about 5 gallons capacity is advisable.

Time to Spray

It is not necessary in a small garden to apply preventive sprays where daily inspections will reveal insect damage as soon as it starts. However, the week-end gardener may find it advisable to, especially if there are extensive gardens close by from which pests might migrate. Cabbages, cauliflowers, and tomatoes may be given preventive sprays to advantage, and it is often advisable to spray the lower surfaces of the leaves of beans to protect the plants against the attack of the Mexican bean beetle.

Spraying may be done at any time during the day, but the spray should not be applied while the leaves are wet as the result of rain or heavy dew. The spray must dry on the plants and once it has dried it usually adheres for several weeks. If washed off by heavy rains, it must be renewed if there is further evidence of insect damage. The new growth, after spraying, is not protected, and this may necessitate further applications. The need for a second or third application can only be determined by the abundance of the pest and a knowledge of its habits.

Never spray more often than necessary, and spray only if it is obvious that control cannot be obtained by hand picking. Remember that insecticides are limited in quantity during the war and that the use of any alternative control measure is a direct contribution to our war effort.

When properly timed, one application should prove sufficient. A second should not be made unless absolutely necessary. Spray only when you feel sure that the increase in yield will much more than pay for the cost of materials. All of the insecticides recommended at the present time can be kept for years without deterioration. Some of the ingredients in insecticides are essential to war industries but they have been made available in order that you may aid in maintaining our food production.

Combination Sprays

It is possible to use all three types of spray—contact, stomach poisons, and Bordeaux mixture—in a single application, and this is often done, though it is wasteful of materials. The best practice is to apply arsenicals and Bordeaux together, since these two give control of all biting insects, as well as of fungus diseases. Contact sprays should be applied separately, and only where needed.

If you desire 6 gallons of spray, use 6 gallons of water but mix in the full amount of the arsenical and Bordeaux just as if you were making 6 gallons of each. For example: 1 oz. arsenate of lime, 1 lb. Bordeaux mixture, 6 gals. water. If the regular amount of water for each insecticide separately were used, the spray would be so dilute as to be ineffective.

Spray Injury

Spray injury results from applying a mixture too strong for tender foliage.

It is usually first apparent on the tips and edges of leaves, where drops of spray have collected and dried. The edges of the leaves dry out, wilt, and turn brown. If the injury is severe, the plant may become defoliated. Damage is most likely to occur when arsenicals or oils are used. Arsenical injury may be prevented by the addition of hydrated lime. The amounts specified in the table are more than adequate.

Dusting

Many insecticides are now applied in the form of a dust. The dusts consist of the various kinds of insecticides diluted with a number of different materials, most of which have some insecticidal value in their own right. The dusts must be applied with a dusting machine, and while in peace-time a number of types are available, few are apt to be procurable during the war. However, some victory gardeners may already own dusters and may prefer dusting to spraying.

Dusting has some advantages, especially in the commercial growing of crops, but the only advantage it offers the small gardener is that it is cleaner. In the long run it is much more expensive, since the materials cost more and more applications are needed. The recognized disadvantages of dusting are that the distribution of materials on the plants is uneven and the dusts wash off more readily than sprays. These disadvantages are more than offset when treatment is on a large scale, particularly where airplane dusting is possible.

Dust must be applied when there is little or no wind. When arsenicals are used alone, the dusting should be done in the morning or evening when there is dew on the plants. Dusting with contact insecticides gives best results during the hottest part of the day, and only when the temperature is above 70° F. However, it may be economical to apply two or more dusts in the same operation.

In general, the same rules must be followed as for spraying, and every effort must be made to get the dust on the under side of the leaves. This is sometimes difficult with low-growing plants.

Suds, Dishwater, and Soap

The use of suds and dishwater for the control of some garden insects, particularly aphids, is often recommended. These materials are of little, if any, value as insecticides. A soap solution, to have satisfactory insecticidal properties, must contain at least 4 pounds of strong soap for each 10 gallons of water, and even at this concentration it is inferior to other

contact sprays or dusts. The amount of soap in dishwater is so small as to be unworthy of consideration.

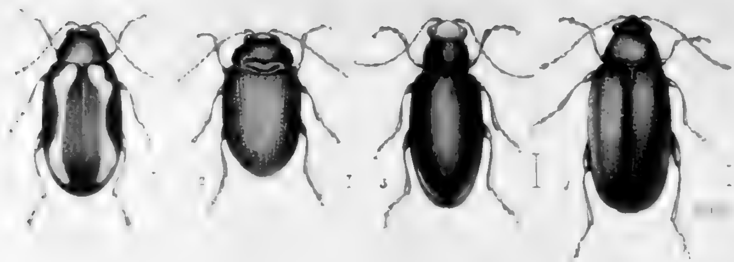
Dishwater usually contains free grease, and this may prove harmful to plants if applied frequently. Those who have lived in the country may recall that the area where dishwater was continually thrown out eventually became bare of grass and only supported the toughest of weeds.

It may be unsanitary to use suds from the washing of clothing. They may contain pathogenic bacteria if some member of the family is suffering from an intestinal ailment.

For these reasons we do not recommend the application of suds and dishwater to plants.

Above, cutworms at base of "cut" plant (life size)

Left, a wireworm (enlarged 3 ×)



1. Striped flea beetle. 2. Potato flea beetle. 3. Red-headed flea beetle. 4. Cabbage flea beetle. (All enlarged; see lines for life size)

General Feeders

Many insects feed upon a great variety of plants, and it is therefore necessary to protect almost every garden from them. Then there are insects, like aphids and flea beetles, which chiefly attack only certain kinds of related plants or groups of related plants, the control in all cases being the same. We treat the control of these under general feeders.

Aphids

These are the true plant lice. There are numerous kinds of them, and few plants are immune to their attacks. Since they are sucking insects, they must be controlled by contact sprays or dusts.

Spray or dust the affected plants with nicotine sulphate at the strength recommended under this insecticide (see table, page 6). Homemade nicotine spray (from cigarette and cigar refuse) may be used. Apply during the hottest part of the day (early afternoon).

Flea Beetles

There are many kinds of flea beetles, each limited to certain plants or groups of plants. They eat small holes in the leaves. All can be controlled in the same way. They may be recognized because they hop like fleas.

Apply Bordeaux mixture, which acts as a repellent. At the same time, it repels many other kinds of insects and is an excellent fungicide.

Cutworms

There are very many kinds of cutworms, which are the larvae of noctuid moths, and their habits are varied. The two that interest us most are the true cutworms, which cut off plants just above the surface of the ground, and the climbing cutworms. These insects bury themselves an inch or less in the soil during the day and come out at night to feed. Fortunately they like some other things more than they do vegetable plants, so it is possible to control them.

The following poisoned bait is very effective when properly applied:

Bran	5	pounds
Paris green	1½	ounces
Molasses	6	ounces
Water	2	quarts

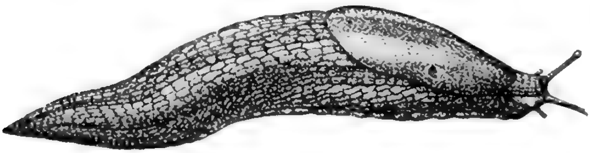
Scatter the Paris green over the top of the bran and stir with a stick or mix with the hand until thoroughly mixed. Dilute the molasses in the water. Pour some of the liquid into the bran and mix well. Continue until the mixture forms a loose, spongy mass when squeezed in the hand but does not all stick together when lifted in the open hand.

Take a handful of the mixture and spread it by a side-arm swinging

motion, allowing it to flow through the fingers. It is to be broadcast over the garden and in weed patches and hedgerows at least six feet beyond the garden limits. Application must be made at night, and the bait may be reactivated the second evening by a light sprinkling of water. The poison may be washed into the soil by a heavy watering. Keep chickens out of the garden for at least 48 hours, or until the poison has been washed away. If there is a heavy rain the first night, the application must be repeated.

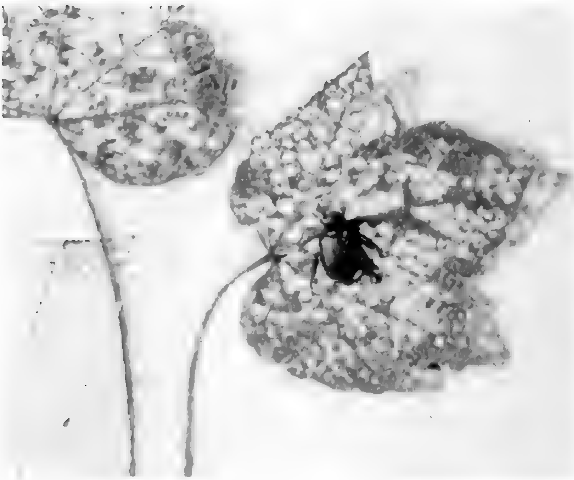
Garden Slugs

These are not insects, but they often cause serious damage in the garden. They are most numerous in damp and shaded gardens. Under commercial conditions spraying may be necessary, but in the garden they may be controlled by placing pieces of board between the rows and destroying the



Above, a common garden slug (enlarged 2 ×)

Right, burdock borer in stem (life size)



Japanese beetle and its work (life size)

slugs found under them in the daytime. Some kinds of slugs are cultivated in Europe as food and are considered a great delicacy.

Wireworms

The larvae of the click beetles are common pests when grasslands have been dug over for the first time. They will attack cereals readily and, in the absence of these, garden plants. They are shiny, reddish-brown, wormlike creatures with hard shells. If many of them are found in digging the garden, control measures should be taken.

They may be trapped by burying pieces of potato about 2 inches under the surface and 10 feet apart. These pieces are dug up about once a week for a month and the wireworms destroyed. The same pieces of potato may be used 2 to 4 times. If shriveled or rotted, they should be replaced. If wireworms are not found after the second application, the procedure may be discontinued.

White Grubs

These are the larvae of June beetles and are readily recognized because they are curved so that the head and tail are close together. They are whitish in color, with a dark digestive tract visible in the middle line.

A usually satisfactory way of controlling them is to pick them at the time of digging and preparing the garden. Chickens and other birds thrive on them and will dig them out of loose soil. Starlings are particularly fond of them, both in autumn and spring. Since, in the absence of cereals, they will attack almost all roots, as many as possible should be destroyed while digging and cultivating. Potato tubers may be destroyed by them.

Grasshoppers

Grasshoppers are not normally a garden pest, but at times they may become so. They may be controlled by use of a bait similar to that employed for cutworms. The difference is that the molasses is replaced by 1½ ounces of salt and another pint of water is added, the bait being quite moist when applied.

Burdock and Potato Stalk Borers

These insects attack a great variety of plants, including many flowers with large stems. In the garden, corn and tomatoes are the most frequently attacked. The tops of the plants wither and die. A single caterpillar may in the course of its migrations cause the death of several plants or branches.

There is no very good control for these borers. The larvae usually migrate from weed patches, and the first evidence of their presence is the withering tips of plants. As soon as these withering tips are noticed the plant should be cut open. The culprit can usually be located at once and destroyed. The destruction of large

Right, the tarnished plant bug (insert is life size)

Below, the four-lined plant bug (insert is life size)

weeds and discarded stems of vegetable plants by allowing them to decay in the compost heap or by burning them in the autumn will greatly aid in control.

Tarnished Plant Bug

There is no satisfactory control for this small shiny bug (*Lygus pratensis*). It feeds on numerous kinds of plants; both adults and nymphs suck the juices. Weeds in and near the garden should be kept down all season. However, if weeds outside the garden are allowed to grow to any extent, they should not be cut, since they will attract the bugs from more valuable plants. Persistent spraying with nicotine might give control but the expense is too great in proportion to the damage that usually results.

Four-lined Plant Bug

This insect (*Poecilocapsus lineatus*) also attacks various kinds of plants in the garden, and it is sometimes a much more serious pest than the tarnished plant bug. It can be controlled by persistent spraying with a contact insecticide.

Other Plant Bugs

There are numerous kinds of plant bugs which vary in size and feeding habits. As a general rule they do not compare in the amount of damage caused with the two mentioned above. However, if present in large numbers they will cause some damage. Some of the smaller kinds are temporarily repelled by Bordeaux mixture, and contact sprays will aid in keeping their numbers down.

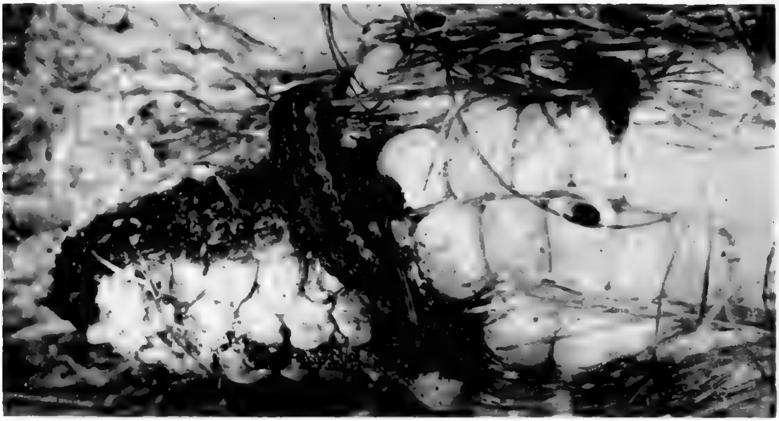
Japanese Beetle

The ravages of the adults of this insect are so well known that no further mention is needed. The beetles prefer certain kinds of crops (and even individual plants of these crops), so only those vegetables that attract many beetles need be sprayed. Hand picking will aid greatly but this may not be sufficient to prevent damage. Weeds around the edges of gardens will attract many beetles, which may then be gathered and killed.

Beetle traps aid in destroying the adults, but they should never be placed in the garden. If used, traps should be placed as far as possible from the garden. Otherwise those not caught in the trap will feed on garden plants. To be fully effective, traps must be used on a community scale.

Some Japanese beetle repellents have been developed but, never having used them, we cannot comment on their actual value.

The feeding of Japanese beetles may be greatly reduced by spraying with arsenicals. When these are used, the spray should contain lime at the rate of 4 pounds to 50 gallons of water since the additional white color has some repellent qualities. To secure best results spray the foliage of all plants in and near the garden upon which the beetles are observed feeding.



The corn ear worm at work (life size)

Work of the carrot rust fly maggot

Potato stem borer at work

Specific Feeders

Corn Insects

Corn has no place in the small victory garden, because it produces so little in proportion to the space required. However, it has its place in large gardens.

Corn is attacked by a goodly number of pests, and there is no completely satisfactory control for any of them. Japanese beetles are particularly attracted to the silk, and when this is gone they are apt to overflow onto other crops.

European Corn Borer

This is undoubtedly our worst pest. The caterpillars of this insect bore into all parts of the corn plant. Control is achieved by the complete destruction of old corn stalks and roots by approximately the middle of May.

Corn Ear Worm

This is the caterpillar of a southern moth that flies north each year and lays eggs on a number of different kinds of plants. On corn the worm usually works near the top of the ear, eating the kernels to the base. We have heard that this insect and the Japanese beetle can be kept from the ears of corn by placing a mothball at the top of the ear, within the leaves, while the silk is still green. It occurs to us that a pinch of tobacco dust (or rotenone dust, if available) might work. Both of these have some repellent qualities.

Carrot, Parsnip, and Celery Insects

There is only one serious pest of these crops. The others may be controlled by hand picking. This is the carrot rust fly. It attacks the roots of carrots in much the same way as the cabbage maggot attacks radishes and turnips. If there are wilted plants at the time of thinning, it is a sign that this insect is at work. Damage is often very serious. The carrot roots show rust-colored, irregular tunnels, caused by the burrowing larvae.

The control is the same as for the radish maggot (page 23).

The greenhouse leaf tier and the swallowtail caterpillar can be controlled in the small garden by hand picking. The former makes silken nets in the leaves of celery and other plants, while the latter is a rather large, green, black-banded caterpillar, the black bands enclosing yellow spots. The adult butterfly is quite beautiful.

Beans are attacked by a number of different insects, the most serious pest being the Mexican bean beetle.

Damage by this insect is inclined to be spotty in the neighborhood of New York. Some patches may be very severely attacked, while others may be wholly free of the pest. It feeds chiefly on the under side of the leaves and may be well established before discovered.

The yellow eggs are laid on the under side of the leaves in clusters. But the presence of yellowish eggs does not prove the presence of the bean beetle, since other lady beetles lay similar groups of eggs, and their larvae are beneficial, since they feed upon aphids. Damage to the leaves is a sure indication.

Hand picking may be sufficient if the attack is light. If severe, either magnesium arsenate or sodium silica fluoride should be applied. Pyrethrum powder is also effective.

The banded flea beetle and the bean aphid are controlled by the sprays for flea beetles and aphids. (See page 13).

Mexican bean beetle at work (life size)

Cabbage maggots on root (life size)

All of these plants are attacked by the same insects, and control measures are practically the same for each. However, the flowers should never be sprayed with arsenicals. Once the cauliflower head forms, there should be no spraying until the leaves have been tied. In the small garden, hand picking will take care of the caterpillars on cauliflowers and cabbages. Rotenone and pyrethrum dusts give satisfactory control of the insects on these plants, but rotenone is not available at present. Many commercial growers use arsenicals in preference to the non-poisonous dusts. Since cabbages are never sprayed after reaching three-foruths of their growth and since the outer leaves containing spray are removed, there is no danger of poisoning. For the peace of mind of the user, the cabbages may be washed in a large pot of water or in running water. Poisons do not adhere well to these plants.

Cabbage Maggot

This is the worst pest during early stages of growth. The treatment consists of pouring a half cup of corrosive sublimate solution around each plant just after it is set out. This is repeated in about a week. When the plants become fully established and the roots harden, they are able to withstand attacks by one or two maggots. See description of the cabbage maggot under *Radish Care* (page 23).

Cabbage Butterflies

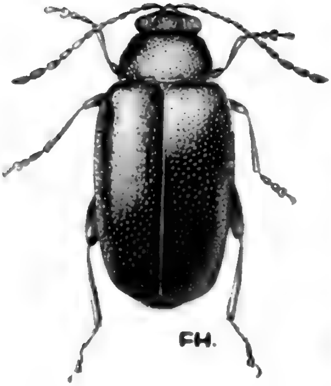
These insects, the imported and southern cabbage butterflies, attack a wide variety of plants and are the cause of serious damage to cabbages and cauliflowers. The larvae eat holes in the leaves and often bore into the heads of cabbages, frequently ruining them. The green leaves of cauliflowers are sometimes completely destroyed and the heads damaged from staining.

The caterpillars are of a soft, velvety-green color and grow to a length of 1¾ inches.

When only a few plants have been set out daily examination and hand picking should prove sufficient. The larvae live on the under side of leaves or hide between them. The presence of holes in the leaves usually indicates the presence of a caterpillar, and it should be searched for until found. Old holes will have a brownish rim and can be ignored. If there are too many plants to care for in this way, sprays or dusts should be applied to the under side of the leaves. A soap sticker must be added to the spray. Arsenicals may be used until about 3 weeks before the crop is harvested. Pyrethrum powder may be dusted on the plants every 10 days to 2 weeks.

Cabbage Looper

This insect causes injury of the same type as the cabbage butterfly, and treatment is the same. A large number of garden plants are attacked,



Cabbage flea beetle (enlarged 13 ×)

Young zebra caterpillars (life size)

Larvae of the cabbage butterfly at work (life size)

including lettuce, beets, celery, and all crucifers. The caterpillars have white lines down the sides and back and move with a clumsy looping motion.

Zebra Caterpillar

Though not an annual pest, this insect when present does enormous damage. It may appear during the spring or in the autumn. The moth lays clusters of yellow eggs on the under side of the leaves, and the young larvae are gregarious. During this time they may be destroyed by removing the leaf on which they are feeding. When they grow older they separate and some of them find their way to other crops and flowers.

Control is the same as for the cabbage butterfly (page 21).

Diamondback Moth

This is a very small moth, with small, green caterpillars. They feed on the under side of the leaves, eating small holes through the epidermis. These show as small, brownish patches.

Control is the same as for the cabbage butterfly (page 21).

Striped Flea Beetle and Cabbage Flea Beetle

The striped flea beetle is small and black, with two wavy yellow lines down the back. The cabbage flea beetle is bright metallic green and is also quite small. All flea beetles hop when disturbed and can be recognized by this characteristic.

Apply Bordeaux mixture, which acts as a repellent.

Turnip Aphid and Cabbage Aphid

These are frequently serious pests of cabbage and cauliflower. The control is the same as is explained under *Aphid Control* (page 13). These insects also attack Brussels sprouts.

Radish Care

Most of the insects attacking cabbages attack radishes, but control measures are seldom necessary, with one exception—the cabbage maggot.

This is the most serious pest of the radish. The adult fly is markedly smaller than the housefly, but only a specialist could identify it. The eggs are laid either on the plants below the surface of the soil or in the soil close to the plants. They hatch in from 5 to 10 days. The maggots feed on the rootlets and later on the taproots, making winding, brownish tunnels and causing the root to become woody and unfit for use. Many of the young plants may be killed.

Control can be exercised when the plants are a few days old by watering with corrosive sublimate solution—about 1 cupful per foot. A large teapot or a small watering can (with the spout plugged enough to control the flow) may be used in applying. Repeat in about a week. If a metal container is used, it must be very thoroughly washed immediately after using; and do not use the teapot unless

it has been washed in a copious amount of hot water. Do not make any treatment after the roots begin to swell.

Turnip Care

One of the chief turnip pests is the cabbage maggot. Treatment is the same as described for this insect under radishes (page 23).

Almost all of the pests that attack cabbages attack turnips. The treatment is the same.

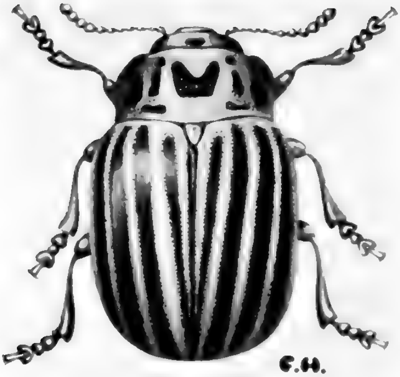
The turnip aphid and the cabbage aphid are frequently serious pests of the turnip, and the control is the same as is explained under *Aphid Control* (page 13).

Potato, Tomato, and Eggplant Insects

Potato Beetle

The Colorado potato beetle attacks other plants too, but it is chiefly a pest of potatoes. Potatoes are not a profitable crop for the small garden, but many week-end gardeners may have space for them. Almost as soon as the potato plants appear they are subject to attack, the foliage being eaten by both the adults and larvae, chiefly the latter. The clusters of orange eggs are usually laid on the under side of the leaves.

Hand picking of adults, larvae, and eggs will serve where the patch is small. In larger patches spray with arsenicals.



Colorado potato beetle (enlarged $3\frac{1}{2}\times$)

Adult potato leaf hopper (enlarged $8\times$)

Onion maggots and work (life size)

Potato Flea Beetle

This insect is often a serious pest of potatoes and tomatoes. The beetles eat small holes in the leaves. They are small and black, with brownish legs.

To control, spray or dust with Bordeaux mixture. Treatment with Bordeaux is an excellent practice, since the material is a fungicide and prevents the development of fungus diseases. It is to be particularly recommended where a garden is shaded and does not receive a good quota of sunlight.

Corn Ear Worm

This is a southern insect and cannot survive the winter in the northern states. But each year millions of the moths move northward; and since each female lays from 500 to 2,500 eggs, it is sometimes a serious pest. It frequently attacks tomatoes, boring into the fruits after they become half grown.

There is no known control, but infested tomatoes should be destroyed when the injury is discovered. The caterpillars will migrate from one fruit to another, and a single caterpillar may destroy several fruits in a bunch.

Tobacco or Tomato Worm

This insect attacks tobacco and is often a serious pest of tomatoes, feeding upon the foliage. It is, when fully grown, a very large, hairless caterpillar with a horn at the tail end. The color is green, with light V-shaped markings pointing toward the head end.

Control by hand picking. In larger patches use arsenicals.

Potato Leaf Hopper

These small, green, tapering, jumping bugs are frequently a serious pest of potatoes, tomatoes, and many other crops. The toxin they inject into the plant causes the leaves to curl and wither, this condition being known as "hopperburn."

Use Bordeaux mixture for control of this insect.

Pea Insects

Pea Moth

This is sometimes a serious pest in Eastern United States and Canada, especially where peas are grown year after year, but it is not likely to attack victory gardens unless close to commercial pea acreages. The eggs are laid at the base of the pea pod. The young larva bores its way in. Once inside, it feeds on the developing peas, sometimes attacking all of those in a pod, and usually causing a mildewy appearance.

Early varieties suffer little damage. The vines should be pulled and destroyed as soon as the crop has been harvested. By picking table peas cleanly when ripe the larvae are destroyed before they reach maturity. If they are a severe pest, peas should not be grown during the following year.

Pea Aphid

The pea aphid is often a very serious pest, especially if there is much clover in the vicinity. When very abundant,

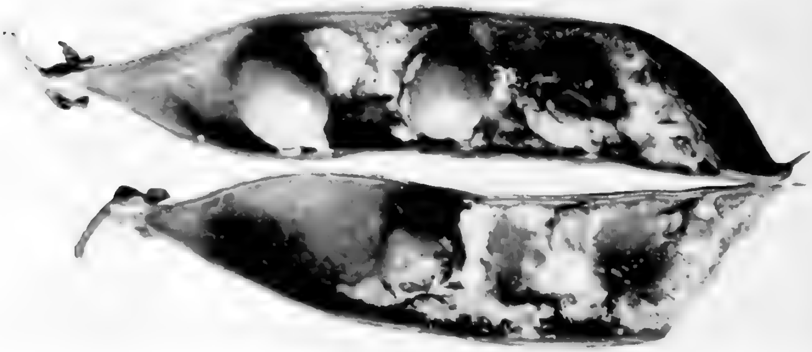
this insect may kill the plants before the crop matures.

Spraying or dusting with nicotine sulphate is recommended for control of the pea aphid.

Pea Weevil

The larvae of this beetle feed within the peas and are not likely to be noticed. They are spread by sowing infested pea seed. Unless sown close to pea acreages the pest is not likely to be troublesome. The use of certified seed is an excellent safeguard and is the only precaution a small gardener can take.

The tobacco worm on a tomato plant (life size)



Larva of pea moth and injured peas

Onion Insects

Onion Maggot

This insect is related to the cabbage maggot, and the two look so much alike in all stages that only an expert can tell them apart. The eggs are laid on the onion stems below the surface of the soil, or in the soil, and the hatching maggots bore into the plants. When abundant they may destroy almost the entire crop. The first attack occurs about the time apple trees come into bloom, and they may continue throughout the summer. The young onion plants suffer most severely, older ones being able to withstand mild attacks, although suffering damage.

The treatment is the same as for the radish maggot (page 23).

Onion Thrips

This is an extremely small, feather-winged insect. The damage is caused by the feeding of the nymphs and adults. Silvery streaks on the onion leaves are a sign of this pest. In cool, wet summers the damage is seldom serious, but hot, dry seasons may result in extreme losses.

To control, spray with ½ pint of nicotine sulphate to 50 gallons of water, using 4 pounds of laundry soap as a spreader. The plants must be well soaked. Repeat if the thrips again become numerous.

When onion sets decay or onions rot they may be infested with various kinds of maggots and beetles. These are not to be considered as pests, but it is advisable to remove and destroy such onions to prevent the attraction of injurious species.

Cucumber, Melon, and Squash Insects

All of these plants are attacked by the cucumber beetle, but this insect is usually unimportant except on cucumbers.

Cucumber Beetle

Both the adults and larvae of this beetle feed on the leaves of cucumbers, and when numerous they may reduce them to mere skeletons. The orange or yellow eggs are laid in clusters on the leaves.

Control by hand picking in the small garden. Dust or spray with arsenate of lime in a large garden.

Squash Bug

This is mainly a pest of pumpkins and squash. The bugs live on the under side of the leaves. Both the adults and nymphs feed there. Since they are sucking insects, no holes are produced, but there are numerous light spots and eventually the whole leaf dies.

Since a large number of eggs are laid on one leaf and the bugs are more or less gregarious while young, the first sign of damage should be followed by an examination of the under side of all the leaves. If one finds eggs (laid in somewhat regular rows) or young

nymphs, the part of the leaf on which they occur should be destroyed. The adults and large nymphs may be picked off by hand. There is no other satisfactory control.

Melon Aphid

The melon aphid is very often a serious pest of melons.

For control, see *Aphid Control* (page 13).

Spinach Insects

A number of insects attack spinach, but few of them are important in the eastern United States.

Spinach Leaf Miner

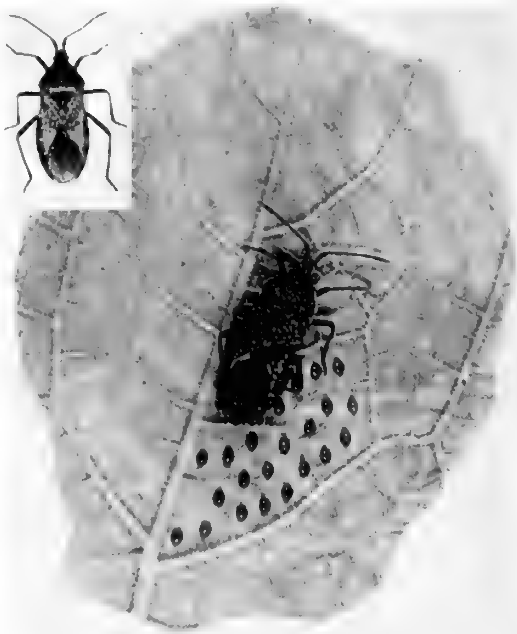
The larvae of a fly mine within the leaves and frequently cause extensive damage. Although eating the larvae will cause no ill effect, most people discard damaged leaves.

To control, destroy all weeds, particularly docks and lamb's-quarters (pigweed). Pick and destroy all spinach leaves as soon as mines are noticed.

Aphids

Aphids and other insects also attack spinach. Aphid control may be advisable (page 13).

Right, squash bug (life size) and female laying eggs (enlarged 1¼ ×)



Adult striped cucumber beetle (enlarged 5 ×)

Control of Ants

Ants are often quite a pest in gardens and their control is not always easy. As a class, ants will eat almost every kind of animal and vegetable matter but they have their preferences. Some like starches, others fats or oils, and others prefer sugars. Because of the great divergence of their preferences, it is difficult to prepare a mixture that will control all the ants in the garden.

The damage caused to plants is varied. Many plants may be destroyed by the building of nests close to them, and portions of the plants may be eaten. Then, some ants carry plant lice to the roots of plants, or from one part of a plant to another. They do this because they like the sweet juices excreted by the aphids. Damage is also caused by the building of large ant hills.

Control measures must be varied. For those ants that like sugar a sweetened bait must be used. A teaspoonful of arsenical or sodium fluoride should be added to a cup of syrup. The poisoned syrup may be poured on the soil near ant nests or placed in containers which may be mostly buried, with holes punched in the top in order to allow the ants to enter.

For control of other ants thoroughly mix a heaping teaspoonful of arsenical or sodium fluoride with 6 to 8 ounces of peanut butter. If there are no children or animals around, place small gobs of the mixture near the ant hills; otherwise place it in containers as above.

To destroy large ant hills, poke three or four deep holes in the hill and drop a tablespoon of calcium cyanide in each, then pack the top of the hill. This should be done in the evening when the ants are all in the nest.

All of these insecticides are poisonous and must be handled with great care.

There are many ant pastes and poisons on the market ready for use. Directions are contained on the packages. Whether they will prove effective in destroying the particular kinds of ants found in your garden can only be determined by trying them.

Beneficial Insects

Only a small percentage of insects are serious pests, and very many of the insects observed in the garden will be helpful in controlling those doing damage. In nature insects are chiefly controlled by other insects, and all pests have parasites. Sometimes these are sufficiently numerous to control the injurious kinds, but as a rule they are just one step behind the pests, and

only occasionally do they become sufficiently numerous to wipe out the insects causing damage.

Some of the most common beneficial insects in the garden are lady beetles and flower flies. The lady beetles feed on plant lice, both as adults and larvae, devouring enormous numbers of them. The flower fly larvae also feed on plant lice and meally bugs and often destroy whole colonies of them. The adult flies resemble wasps. Wasps are very valuable, since they catch other insects with which to feed their young. Bees, flies, and some moths—in fact, any insects that visit flowers—help to pollinate the flowers and thus are instrumental in producing crops. Ground beetles are almost all beneficial, feeding upon other insects; but since they are mostly nocturnal, they will not be seen very often.

We are unable, here, to devote much space to beneficial insects but we think that the gardener will soon learn to distinguish between the good and bad ones if they are abundant. If doubtful about an insect's habits, observe its actions. If it is a pest it will soon demonstrate the fact. Proper action can then be taken.

Control of Fungus Diseases

Although fungus diseases are beyond the scope of insect control, we include them here because the same spray, Bordeaux mixture, is used. In addition to this, there may be times when fungus will cause more trouble than insects.

Bordeaux mixture has long been used as a fungicide. Unfortunately Bordeaux will clog sprayers that do not have an agitator; but if a small hand sprayer is shaken frequently, little trouble will be experienced.

Prolonged periods of dampness are ideal for the development of fungus diseases. The use of Bordeaux will often prevent the loss of crops through fungus diseases and insect-carried viruses. It is because of this that its use is recommended along with arsenical sprays and dusts.

Mildews on plants may be prevented or controlled by dusting with sulphur. Sulphur used for dusting is of a fine quality; coarser sulphur should not be used.

Fungus diseases are spread in many ways, but the spores are carried chiefly by wind, by insects, and in manure.

Several commerical preparations are available for treating seeds to destroy fungus spores and for treating the soil against "damping off"—a germ disease of seed beds, which may destroy a fine looking crop of seedlings in a few hours. Directions for use of these materials are contained on the packages, which may be obtained from your seed dealer. Your State Botanist may be able to furnish additional information. on the subject.

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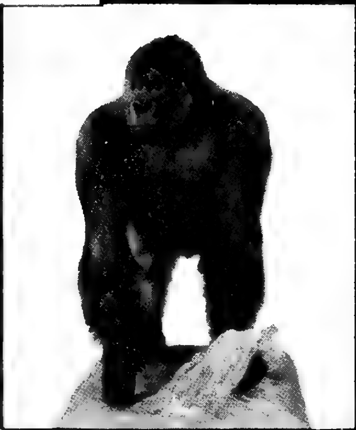
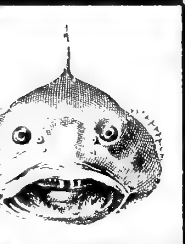
Boldface numerals indicate illustrations

THE AMERICAN MUSEUM OF NATURAL HISTORY





general GUIDE

ONE DOLLAR

general GUIDE

to THE AMERICAN MUSEUM OF NATURAL HISTORY

SCIENCE GUIDE NO. 118

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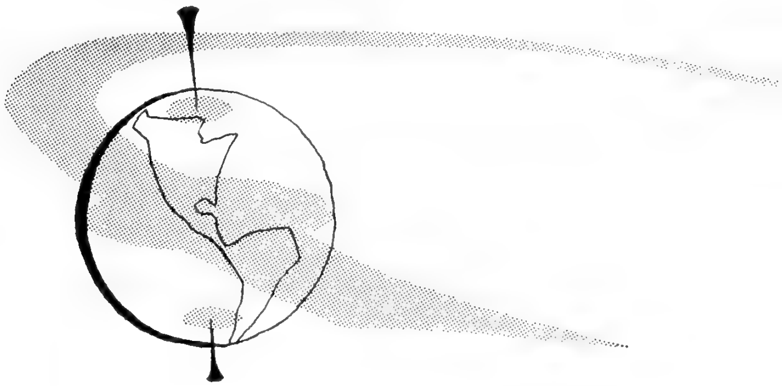


AN INTRODUCTION TO THE AMERICAN MUSEUM OF NATURAL HISTORY

The ideal museum has been dreamed of but has not yet been built. The ideal museum presents, in logical order, the entire story of the universe, the earth, and its inhabitants, together with their total relation to each other. Practical limitations prevent such a museum from becoming a reality but the goal is there.

The American Museum of Natural History works constantly toward that goal. A study of the table of Contents of this General Guide will give the Museum visitor a key to an appreciation of its offerings in both a logical and a chronological order.

Astronomy mirrors the universe and states the theories of the earth's origin. The hardened rocks furnish the material of geology and the life-forms trapped in that rock are the objects of the paleontologist's search. From fossils we advance to forms that are familiar today — living creatures without backbones, insects, fishes, reptiles, birds, and mammals — all leading to the study of man himself.

With the growth of man from primitive savagery to what we call civilization, come changes in his relation to his surroundings. The first living thing was affected by its environment and affected it in turn. Man

is no exception. He is one of a species of animals, among which he is no more necessary to the continuance of life than are the insects, the birds or the dinosaurs. His very existence in the future may depend on his understanding of the world in which he finds himself.

Man is still a part of nature, although he controls much on earth. He is still subject to great basic laws and forces that restrict and restrain him within marked boundaries. A shift in climate from marine temperate to glacial cold could wipe out the traces of man and his works over a continent. A movement of the ocean bed could send a tidal wave to destroy coastal towns thousands of miles away.

Closer to man's fate than great earth changes are the difficulties he makes for himself through lack of understanding of the consequences of his acts. Because he is the only living organism with the powers of reason developed to a relatively high degree, he is able to engage in thought-processes and actions that create in him needs and desires that were not shared by his early ancestors. In the satisfaction of these needs and desires he cuts down whole forests for his industries. He mines the soil and uses up resources he cannot hope to replace. He waters the desert and reaps his harvest. He plows the plains and sows the dust bowls.

The Museum is aware of the urgency of the problems of soil, water, forest, mineral and wild life conservation and of the conservation of man himself. As you read through this General Guide or walk through the Museum halls, note the theme expressed by those who represent the many departments of science and of education. This idea is plain in their research, in their writings and in their exhibits for the public. The scientist-educator is concerned with the interpretation of nature rather than with its mere presentation. The day of the thousand stuffed animals in one long case is gone. The scientist-educator knows that man must see nature as a whole since he must live as a whole being within its framework.

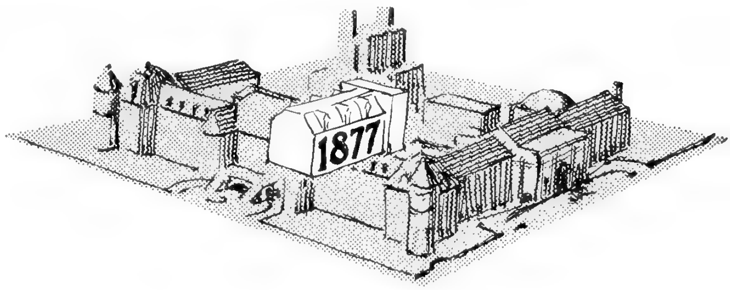
The American Museum of Natural History is one of the most wonderful places in the world. It houses the priceless objects of the earth, displayed in dramatic settings that amaze and delight all who come to see.

But it is more, much more, than a treasure trove of the rare, the exotic, the beautiful and the unusual. It is a great teacher who can tell man what has gone before, what exists in the present, and what the future holds, depending on man's choice of direction. It would not be a great teacher if it did not indicate the best direction for him to take.

The Museum should be all things to all men. It should meet the needs of the housewife, the farmer, the industrialist, the teacher, the college student, the child. Each must find, among its offerings, an answer to his questions, an understanding of daily living and an appreciation of his own place in a highly complex and interrelated world.

Unless museums work toward that objective, they fail in their obligation to mankind. This museum realizes that responsibility and asks you, the visitor, to pass judgment on the fruits of its labors and to take some of those fruits with you.

GENERAL INFORMATION



The American Museum of Natural History is located in Manhattan Square and occupies most of the space between Central Park West, Columbus Avenue, 77th Street, and 81st Street. The main entrances are on Central Park West, through the Roosevelt Memorial, at three levels: street, vehicle (driveway under the steps) and subway. There is also an entrance on West 77th Street (foot and vehicle) in the center of the block.

The Planetarium may be entered from West 81st Street (foot and vehicle) and through the Museum. Cars may be parked at the curb on the streets surrounding the Museum Square.

ADMISSION

There is no charge for admission except to The American Museum — Hayden Planetarium. The Museum is open to the public from 10:00 A.M. to 5:00 P.M. daily except Sundays, Thanksgiving Day, Christmas, New Year's Day and July 4th, when it opens from 1:00 P.M. to 5:00 P.M.

MEMBERSHIP

There are about 37 thousand members of the American Museum of Natural History who believe that the Museum is doing a useful service to science and to education and who are contributing to this work. Through its explorations the Museum brings together rare and valuable collections from all over the world. It makes these wonders of nature easily available through its exhibition halls, its lectures, its work with school children, and its publications. The continuance and growth of this work is, in large measure, dependent upon the contributions of friends.

The Trustees invite you to lend your support by becoming a member.

Membership blanks may be obtained at the information desks, in

the American Museum Shop, or by dropping a postcard to the Membership Secretary, The American Museum of Natural History, Central Park West at 79th Street, New York 24, N. Y.

Memberships may start at any time. Associate, Annual, Sustaining, Contributing and Supporting memberships continue for a full year's period from the date annual dues are paid. Life and higher class memberships are valid throughout the lifetime of the member.

The various classes of membership, with the dues payable by and the privileges accorded to each class, are as follows:

Class	Dues	Privileges
Associate	$ 5 yearly	1 through 5
Annual	15 yearly	1 through 6 plus choice of 7 or 8
Sustaining	25 yearly	1 through 8
Contributing	50 yearly	1 through 8
Supporting	100 yearly	1 through 8
Life	300	1 through 10
Associate Patron	1,000	1 through 10
Patron	5,000	1 through 10
Associate Benefactor	10,000	1 through 10
Associate Founder	25,000	1 through 10
Benefactor	50,000	1 through 10
Founder	100,000	1 through 10

Privileges

1. A Membership Card.

2. A year's subscription to *Natural History* magazine.

3. Ten per cent discount on all books on sale in the American Museum Shop.

4. Admission to the Members' Room.

5. A copy of the President's Annual Report on request (Life and higher class members receive the Annual Report automatically).

6. Two admissions yearly to performances of the American Museum-Hayden Planetarium.

7. Admission to all Members' Lectures (10 or more annually), with guest tickets permitting members to invite one guest to each lecture.

8. Admission to all Lectures in the Adventure Series for children of members (10 or more annually), with two guest tickets for each lecture.

9. A handsomely engraved Certificate of Membership, suitable for framing.

10. Admission to special staff functions arranged for higher class members.

HOW TO REACH THE MUSEUM

By Bus: Eighth Avenue or Columbus Avenue Bus to 77th Street.

79th Street Crosstown Bus to 81st Street and Central Park West.

By Subway: Broadway-Seventh Avenue Line to 79th Street and Broadway Station (local stop). Walk two blocks east to Columbus Avenue and 77th Street.

Sixth and Eighth Avenue Lines to 81st Street Station (local stop).

Lexington Avenue Line to 77th Street Station (local stop), then Crosstown Bus from East 79th Street directly to 81st Street and Central Park West.

Groups coming by bus should direct the bus driver to let them out at the 77th Street entrance. Busses can be parked in the area next to the American Museum-Hayden Planetarium. When leaving, busses should pick up their groups at the 77th Street entrance.

Visitors arriving in private cars may park in the area next to the American Museum-Hayden Planetarium. There is room for about one hundred and fifty cars.

CHECK ROOMS AND GUEST SERVICES — INFORMATION DESKS

The main check room is on the right as one enters the main entrance on the first floor of the Roosevelt Memorial (driveway under the steps). Coats and packages may be left here. Wheel chairs are available free of charge. There is also a check room at the left of the 77th Street entrance. There is no charge for checking.

Information desks are located on the main (second) floor of the Roosevelt Memorial, in the 77th Street foyer, and facing the entrance to the Eighth Avenue Subway.

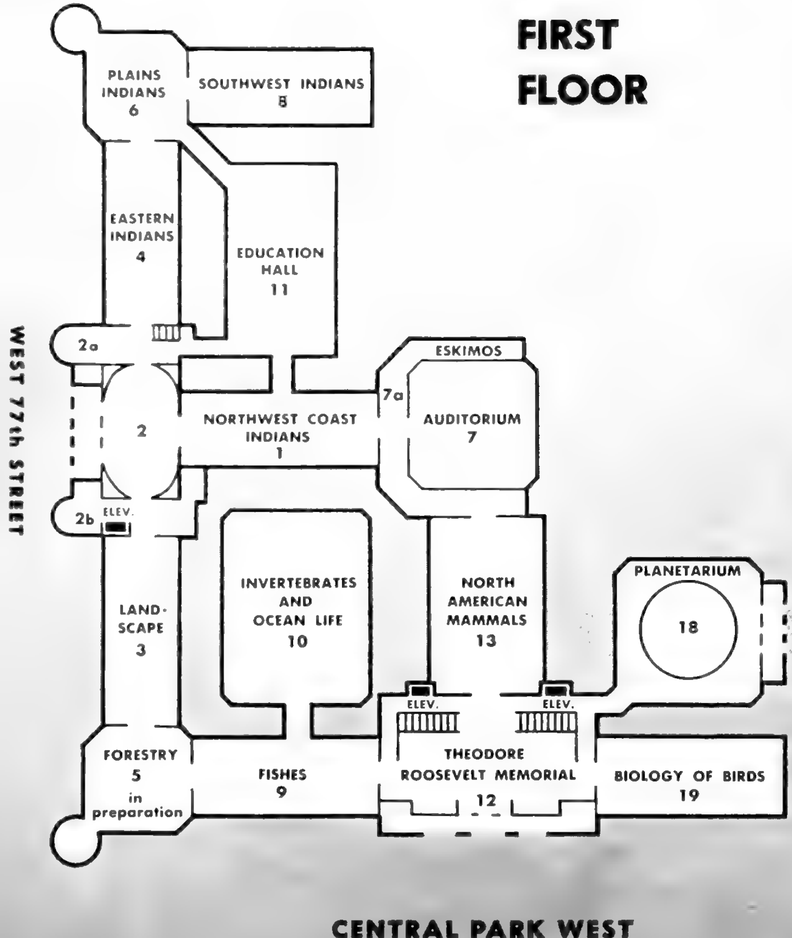
THE AMERICAN MUSEUM SHOP

The entrance to the American Museum Shop is near the 77th Street entrance, next to the elevators. Unusual gifts from all over the world — authentic examples of native handicraft, pottery, masks, Indian silver jewelry, dolls and carved objects — are on display. Specimens for the shell and mineral collector are kept in stock. A representative list of books, covering the many fields of the natural sciences, is also available.

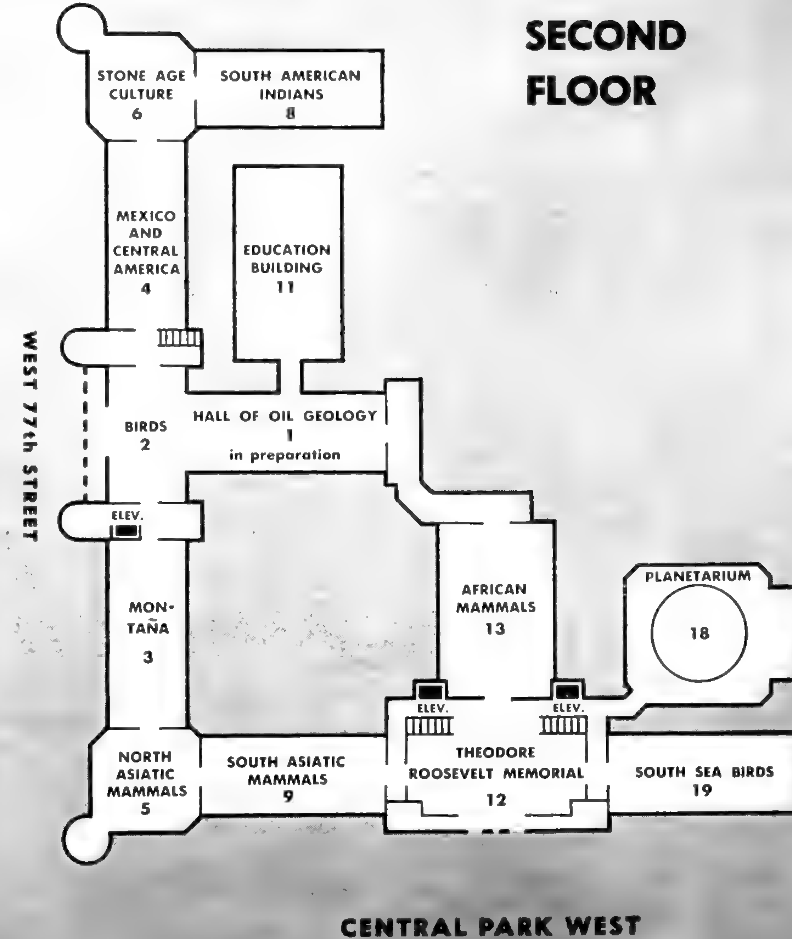
FLOOR PLANS

Pictorial plans of the Museum exhibits are posted near the elevators and at convenient points throughout the Museum to guide visitors to the various halls. Also see the next four pages.

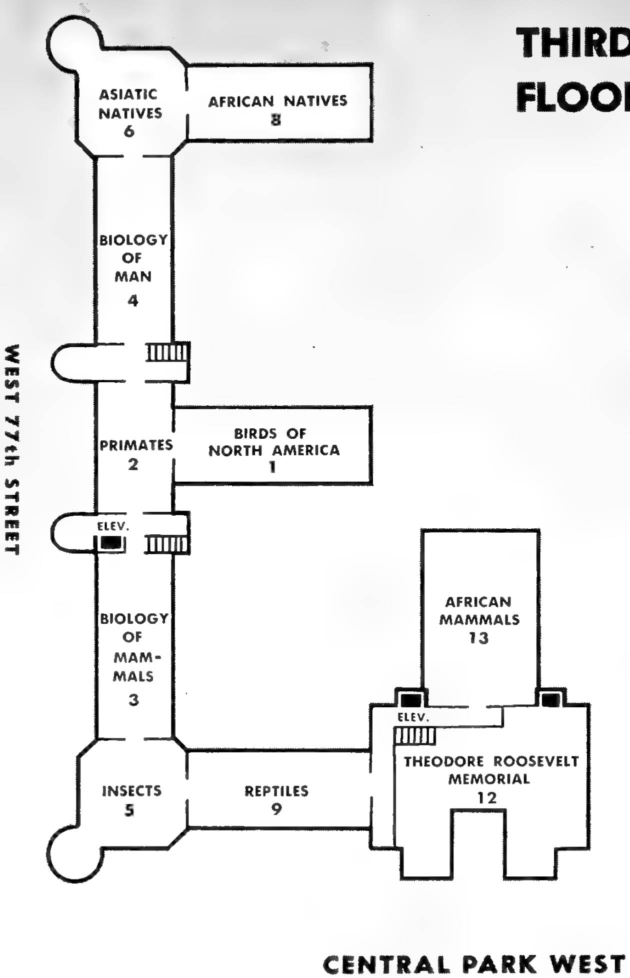
FIRST FLOOR



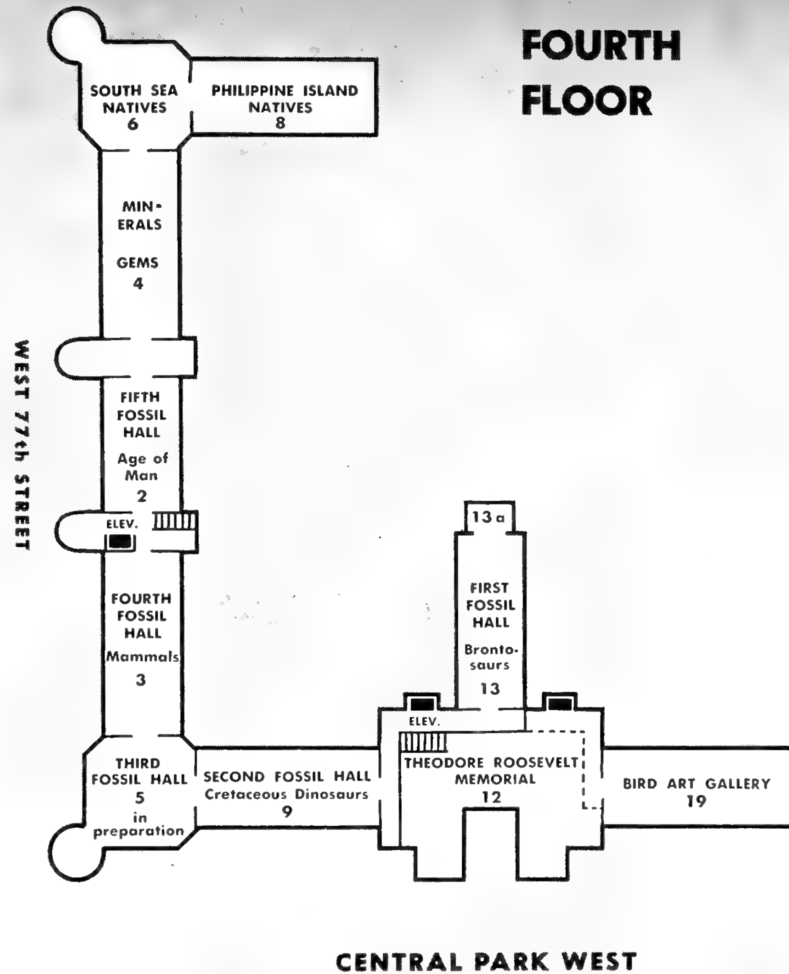
SECOND FLOOR



THIRD FLOOR



FOURTH FLOOR



LOCATIONS OF EXHIBITS AND SERVICES

AFRICAN MAMMALS. 2nd & 3rd Floors, Halls 13.

AFRICAN NATIVES. 3rd Floor, Hall 8.

AMERICAN MUSEUM-HAYDEN PLANETARIUM. 1st Floor, Hall 18. (Main entrance from 81st St.).

AMPHIBIANS (FOSSIL). 4th Floor, Hall 13.

AMPHIBIANS AND REPTILES (LIVING). 3rd Floor, Hall 9.

ANTHROPOLOGY.

African Natives: 3rd Floor, Hall 8.
Age of Man: 4th Floor, Hall 2.
Asiatic Natives: 3rd Floor, Hall 6.
Biology of Man: 3rd Floor, Hall 4.
Eskimo: 1st Floor, Hall 7a.
Indians of North America: 1st Floor, Halls 1, 4, 6 and 8.
Indians of Mexico & Cent. America: 2nd Floor, Hall 4.
Indians of South America: 2nd Floor, Hall 8.
New Zealand Natives: 4th Floor, Hall 8.
Philippine Natives: 4th Floor, Hall 8.
South Sea Natives: 4th Floor, Hall 6.
Southeast Asia Natives: 4th Floor, Hall 8.
Stone Age Culture: 2nd Floor, Hall 6.
Tibetan Exhibit: 3rd Floor, Hall 6.

ARCHAEOLOGY. 2nd Floor, Halls 4, 6 and 8.

ASIATIC MAMMALS. 2nd Floor, Halls 5 and 9.

ASIATIC NATIVES. 3rd Floor, Hall 6.

AUDITORIUM. 1st Floor, Hall 7.

BIRDS (FOSSIL). 1st Floor, Hall 19.

BIRDS (LIVING).

Biology of Birds: 1st Floor, Hall 19.
Birds of North America: 3rd Floor, Hall 1.
Birds of the World: 2nd Floor, Hall 2.
Local Birds: 1st Floor, Hall 12.
Pacific Bird Life: 2nd Floor, Hall 19.

BUTTERFLIES. 3rd Floor, Halls 3 and 5.

CAFETERIA. Basement, Hall 12. For teachers and children, Basement, Hall 11. See also Snack Bar.

CONSERVATION. 1st Floor, Halls 3 and 5.

CORNER GALLERY. 2nd Floor, Hall 5.

DINOSAURS. 4th Floor, Halls 9, 12 and 13.

DRUMMOND COLLECTION OF JADE. 4th Floor, Hall 6.

DUPLEX HALL. 2nd Floor, Hall 11.

ECOLOGY. 1st Floor, Hall 3 and 5.

EDUCATION HALL. 1st Floor, Hall 11.

ELEVATORS. Halls 2 and 12.

ESKIMO. 1st Floor, Hall 7a.

FISHES (FOSSIL). 4th Floor, Halls 5 and 13a.

FISHES (LIVING). 1st Floor, Hall 9.

FORESTS. 1st Floor, Hall 5.

GEMS AND MINERALS. 4th Floor, Hall 4.

GEOLOGY OF DUTCHESS COUNTY. 1st Floor, Hall 3.

HAYDEN PLANETARIUM. 1st Floor, Hall 18. (Main entrance from 81st St.).

INDIANS OF MEXICO & CENTRAL AMERICA. 2nd Floor, Hall 4.

INDIANS OF NORTH AMERICA. 1st Floor, Halls 1, 4, 6 and 8.

INDIANS OF SOUTH AMERICA. 2nd Floor, Hall 8.

INFORMATION DESKS. Basement, Hall 12; 1st Floor, Hall 2; 2nd Floor, Hall 12; and by all elevators, Halls 2 and 12.

INVERTEBRATES (FOSSIL). In preparation.

INVERTEBRATES (LIVING). 1st Floor, Hall 10.

INSECTS AND SPIDERS. 3rd Floor, Halls 3 and 5; 1st Floor, Hall 12.

JADE, DRUMMOND COLLECTION OF. 4th Floor, Hall 6.

LANDSCAPE HALL. 1st Floor, Hall 3.

LECTURE AND MEETING ROOMS.

Auditorium: 1st Floor, Hall 7
Duplex Hall: 2nd Floor, Hall 11.
Portrait Room: 2nd Floor, Hall 12.
Room 129: 1st Floor, Hall 12.
Room 319: 3rd Floor, Hall 12.
Room 419: 4th Floor, Hall 12.
Room 426: 4th Floor, Hall 12.
Roosevelt Lecture Room: 5th Floor, Hall 12.
Sportsmen's Library: 2nd Floor, Hall 12.

LIBRARY. 5th Floor, Hall 2.

MAMMALS (FOSSIL). 4th Floor, Halls 2, 3 and 5.

MAMMALS (LIVING).

African: 2nd and 3rd Floors, Hall 13.
Asiatic: 2nd Floor, Halls 5 and 9.
Biology of Mammals: 3rd Floor, Hall 3.
Hall of Ocean Life: 1st Floor, Hall 10.
New York State: 1st Floor, Hall 12.
North American: 1st Floor, Hall 13.
Primates: 3rd Floor, Hall 2.

MAN.

Age of: 4th Floor, Hall 2.
Biology of: 3rd Floor, Hall 4.
Origin of: 4th Floor, Hall 2; 3rd Floor, Hall 4.

MEXICAN & CENTRAL AMERICAN ARCHAEOLOGY. 2nd Floor, Hall 4.

MINERALS AND GEMS. 4th Floor, Hall 4.

MONTAÑA, MEN OF THE. 2nd Floor, Hall 3.

MUSEUM SHOP. 1st Floor, Hall 2b.

NEW ZEALAND NATIVES. 4th Floor, Hall 8.

NORTH AMERICAN MAMMALS. 1st Floor, Hall 13.

OCEAN LIFE, HALL OF. 1st Floor, Hall 10.

PACIFIC BIRD LIFE. 2nd Floor, Hall 19.

PHILIPPINE NATIVES. 4th Floor, Hall 8.

PLANETARIUM. 1st Floor, Hall 18. (Main entrance from 81st St.).

PLANT COMMUNITIES. 1st Floor, Halls 3 and 5.

POLAR EXPLORATION. 1st Floor, Hall 2.

PRIMATES. 3rd Floor, Hall 2.

PUBLIC INSTRUCTION. 3rd Floor, Hall 11. (And Basement).

REPTILES (FOSSIL). 4th Floor, Halls 5, 9, 12 and 13.

REPTILES (LIVING). 3rd Floor, Hall 9; 1st Floor, Hall 12.

SCHOOL SERVICE. 3rd and 4th Floors, Hall 11. (And Basement).

SHOP. 1st Floor, Hall 2b.

SNACK BAR. 2nd Floor, Hall 2.

SOUTH AMERICAN INDIANS & ARCHAEOLOGY. 2nd Floor, Hall 8.

SOUTH SEA NATIVES. 4th Floor, Hall 6.

SOUTHEAST ASIA NATIVES. 4th Floor, Hall 8.

SPIDERS. 3rd Floor, Hall 5.

SUBWAY. Basement, Hall 12.

THEODORE ROOSEVELT MEMORABILIA. 2nd Floor, Hall 12.

THEODORE ROOSEVELT MEMORIAL. 1st to 5th Floors, Hall 12.

TIBETAN EXHIBIT. 3rd Floor, Hall 6.

WHALE MODEL (LIFE SIZE). 3rd Floor, Hall 3.

SKETCHING AND PHOTOGRAPHING

Chairs for artists and students who wish to draw from exhibits may be had by asking the nearest attendant. Amateur photographers may get permission from any information desk to take pictures in the Museum halls. Professional photographers may get permission from the Division of Photography. The use of a tripod and careful exposure with a light meter is recommended for most Museum photography.

GUIDING

Free Guiding Service: In addition to the regularly scheduled educational programs of the Department of Public Instruction, free guiding is given to Members of the Museum and their friends, upon presentation of Members' tickets. An appointment should be made at least two weeks in advance, stating the day and hour desired, the number to be guided and any special exhibits to be seen.

Paid Guiding Service: This is available for non-members of the Museum according to the following schedule:

1-4 persons	minimum charge $2 per hour
4-9 persons	$2 per hour plus 50¢ each additional person up to and including 9 persons
10-30 persons	$5 per hour
30-60 persons	$10 per hour (services of 2 Museum instructors)
60-90 persons	$15 per hour (services of 3 Museum instructors)

Guiding is available on weekdays after 2 P.M. There is no guiding on Saturdays, Sundays and holidays. For appointments call TRafalgar 3-1300, Extension 255.

CAFETERIAS

The Main Cafeteria is convenient to the subway entrance in the Roosevelt Memorial. It is open from 11:30 A.M. to 4:30 P.M. daily and from 1:00 P.M. to 4:30 P.M. on Sundays. It is closed on the following holidays: Christmas Day, New Year's Day and Thanksgiving Day.

On Saturdays, Sundays and holidays, except those mentioned above, the Auxiliary Cafeteria on the second floor, above the 77th Street Entrance, is open as a snack bar from 1:30 P.M. to 4:30 P.M.

THE LIBRARY

The Library is on the fifth floor of the Museum. It is devoted to works on natural science, exploration and travel and contains some 145,000 volumes which comprise not only the important periodicals of our own and foreign countries but also all representative and standard works on zoology, physical anthropology, ethnology, pre-history, archae-

ology, geology, and paleontology. The collection on vertebrate paleontology forms the Osborn Library of Vertebrate Paleontology, founded by President Henry Fairfield Osborn.

The Reading Room of the Library is open to the public from 10:00 A.M. until 4:00 P.M., except on Sundays and holidays. The Library is also closed on Saturdays from June to September. Those interested in consulting books and periodicals are welcome to do so during the available hours.

PUBLICATIONS

The publications of the American Museum fall into two groups: technical and popular.

The technical publications, comprising the *Bulletin*, *Anthropological Papers, Memoirs* and American Museum *Novitates,* contain information gathered by the various expeditions or derived from the study of material collected. The *Bulletin* contains the larger scientific papers, covering records of exploration and collections of the Museum. The *Anthropological Papers* are devoted to researches in the study of man, supervised by the Museum's Department of Anthropology. The *Memoirs*, quarto in size, contain monographs, many of which require large illustrations. The *Novitates* include the shorter scientific contributions, descriptions of species, etc., which demand immediate publication. The scientific publications are distributed to libraries of scientific institutions and societies throughout the world, largely on an exchange basis. Inquiries may be directed to *Editor — Scientific Publications.*

The popular publications include *Natural History* magazine, *Junior Natural History* (a children's magazine), and *Man and Nature* Publications. The purpose of all these publications is to give the public accurate and interesting information in all fields of natural science.

Man and Nature Publications deal with exhibits of particular interest and with the many natural science fields, edited for reading by the layman. More than 140 of these booklets, guides and leaflets have been issued and new ones are constantly in preparation. The *Handbooks*, fifteen of which have been issued, deal with themes related to the collections and are frequently used as textbooks.

A catalogue of the popular publications of The American Museum of Natural History will be sent free on request. (Address: Man and Nature Publications, The American Museum of Natural History, Central Park West at 79th Street, New York 24, N. Y.)

An Annual Report is issued yearly.

THE HISTORY AND WORK OF THE MUSEUM

The American Museum of Natural History was founded and incorporated in 1869 for the purpose of establishing a Museum and Library of Natural History; of encouraging and developing the study of Natural Science; of advancing the general knowledge of kindred subjects and of furnishing popular instruction. For eight years its home was in the Arsenal in Central Park.

The cornerstone of the present building in Manhattan Square was laid in 1874 by President Ulysses S. Grant. In 1877, the first section (South Central Wing) was completed and on December 22nd, 1877, it was formally opened by President Rutherford B. Hayes.

The educational work with the schools was begun in 1880 by Professor Albert Bickmore.

THE MUSEUM'S FIRST UNIT, COMPLETED IN 1877.

The Museum building is one of the largest municipal structures in the City of New York. The South Facade is 710 feet in length and the present East Facade, on Central Park West, is 600 feet. When completed, the building is designed to occupy all of Manhattan Square.

The building is largely erected and maintained by the City, through the Department of Parks. The Roosevelt Memorial section was the gift to the City by the State of New York as its monument to Theodore Roosevelt. The Whitney Wing was built jointly by the late Harry Payne Whitney and the City of New York. The American Museum-Hayden Planetarium was financed by funds loaned by the Reconstruction Finance Corporation of the Federal government. The annual City appropriation, known as the Maintenance Fund, is devoted to the care and upkeep of the building and the safeguarding of the collections.

The Museum is under the control of a self-perpetuating Board of Trustees, which gives its services.

The scientific and educational work is carried on by twelve departments, each headed by a Chairman or Curator, under the leadership of the Director.

The funds through which specimens are purchased, exhibits made, explorations carried on and scientific investigations conducted are contributed by the Trustees, members and other friends. The scientific and popular publications of the Museum and the enlargement of the Library are also made possible through these contributions.

For the benefit of the public, the halls of the Museum are given over to the large series of exhibits which are partially described in this guide book. These are supplemented by lectures and publications of a popular nature. Special motion picture showings are given on Wednesday and Saturday afternoons except from June through September. An important course of evening lectures is given every Spring and Fall for the members, also Saturday morning courses of special lectures for children of members. All lectures are illustrated by motion pictures or Kodachrome slides, many of which have been taken on Museum expeditions. Two auditoriums within the Museum are in use for public showings — the Main Auditorium on the first floor and the Roosevelt Lecture Room on the fifth floor of the Roosevelt Memorial.

OFFICES AND LABORATORIES

The fifth floor of the Museum houses administrative offices, work rooms and the laboratories of most of the Scientific Departments. On this floor are the work rooms of the Department of Vertebrate Paleontology, where the skeletons of fossil animals are prepared and mounted and the beautiful models of invertebrates are made. These, like the other laboratories, are, of necessity, not open to the public.

On the sixth floor of the African section are the well-equipped laboratories devoted to experimental biological research and to physiology and life histories based on the study of living animals.

Most of the scientific study collections are on the fifth floor. The e are for the benefit of investigators and to preserve the evidences and records of our vanishing animal life and the lives and customs of primitive peoples.

The vast majority of the Museum's natural science specimens is in study collections to protect them from damage and for ready use by scientific investigators. A careful selection is made of objects of greatest educational value and these form the basis of the Museum di plays in its exhibition halls.

The Lerner Marine Laboratory

The Lerner Marine Laboratory was established in 1947 by Mr. Michael Lerner to further field studies in marine biology through the

Department of Fishes and Aquatic Biology. Located on the island of Bimini, almost sixty miles due east of Miami, Florida, the laboratory occupies about two and one-third acres on which are the laboratory building, a residence for workers, a storehouse and a power house.

The laboratory building contains four laboratories, a study, two combined aquarium and lab rooms, an animal room, a refrigerator room, a constant temperature room and a photographic dark room. Glass bottomed boats, diving equipment, seines and nets and other facilities are available for researchers. A limited number of applications are accepted yearly by the Museum for workers who wish to use the laboratory facilities.

Genetics Laboratory

Another laboratory within the Museum is engaging in experiments on the hereditary patterns of tropical fish, the results of which are being used to determine the influence of heredity in cancer.

Fish-raising enthusiasts, familiar with the problems of cross-breeding Mexican platyfish and common swordtails, know that the spotted hybrids often develop tumors. Experiments have been going on for over twenty-five years to find the source of these tumors.

When two pure strains of the platy were bred — one with black pigmented spots and the other unspotted — the first-generation platyfish would necessarily be spotted. The spotted pattern is a dominant trait and the unspotted pattern recessive. The black spots are inherited in accordance with Mendel's law of heredity. A cross-bred hybrid from an unspotted platy of the second generation and an unspotted swordtail is unspotted and normal.

When a spotted platy is crossed with an unspotted swordtail, the hybrids have tumors identified as black cancer or melanoma. The findings show that the swordtails carry dominant modifying genes which interact with the blackspot-carrying genes of the platy, so that the black cells of the hybrid develop cancer.

The next experiments were made with one species, the platy, and proved that black cancer in fish is hereditary. The facts derived from such experiments are being used to determine a possible basis for control of those types of cancer that are inherited in man.

The laboratory for this research is housed in the American Museum and is directed by the geneticist of the New York Zoological Society and supported by a grant from the National Cancer Institute of the U. S. Public Health Service.

WORKSHOPS

An important part of the Museum not seen by the public are the workshops in the basement of the building. Provided with machinery of the latest pattern, workmen make the various types of cases used, build and repair the Museum's furniture and make required installations for the exhibition halls.

ENTERING THE MUSEUM

Fifty-eight halls of the Museum are now open to public exhibition. The visitor begins his trip through this immense treasure house of natural science from one of three directions: through the Roosevelt Memorial (page 3), through the American Museum-Hayden Planetarium (page 3), or through the South, or 77th Street Entrance.

The Theodore Roosevelt Memorial

The Theodore Roosevelt Memorial forms the main entrance to the Museum on Central Park West. Its graceful architecture follows a stately Romanesque design.

The facade of the Memorial is set off by four Ionic columns 54 feet high, representing Boone, Audubon, Clark and Lewis, pioneers in the early exploration of our country. A massive equestrian bronze of Theodore Roosevelt by J. E. Fraiser, stands before the entrance arch. On either side of him stand an American Indian and an African native.

Passing through the central archway, the visitor stands in the great Memorial Hall. Above the marble mosaic floor, walls of cream-colored marble and limestone rise to an elaborate Corinthian cornice over-arched by an octagonal coffered barrel-vault 100 feet above the floor. The

THE THEODORE ROOSEVELT MEMORIAL HALL.

central part of each wall is recessed and divided into three parts by two Roman Corinthian columns 48 feet high supporting the entablature. Three of these recesses are adorned with great mural paintings symbolic of the varied career of Theodore Roosevelt. On the wall, quotations from his writings are given in bronze letters.

The Theodore Roosevelt Memorial was erected by the people of the State of New York in memory of the man whose name it bears.

South Entrance Archway

Under the arch on 77th Street, before entering the Museum doorway, may be seen the Bench Mark established by the United States Geological Survey in 1911, on which are inscribed the latitude and longitude, 40°46′47.17″ N., 73°58′41″ W. and height above sea level, 86 feet.

On the right is a GLACIAL POT HOLE from Russell, St. Lawrence County, N. Y., formed by an eddy in a stream beneath the melting ice of the glacier that once covered northern New York State. Pebbles, whirling around the eddy, cut and ground this hole which is two feet across and four feet deep.

GLACIAL GROOVES. On the left is a large slab of fossil-bearing limestone from Kelly Island in Lake Erie, near Sandusky, whose surface has been smoothed, grooved, and scratched by the stones and sand in the bottom of the vast moving ice sheet that covered northeastern North America during the Glacial Epoch.

On either side of the archway are the two largest beryl crystals ever quarried. They were cut in Albany, Maine. These six-sided crystals show the typical aquamarine color in their clearest portions.

Memorial Hall

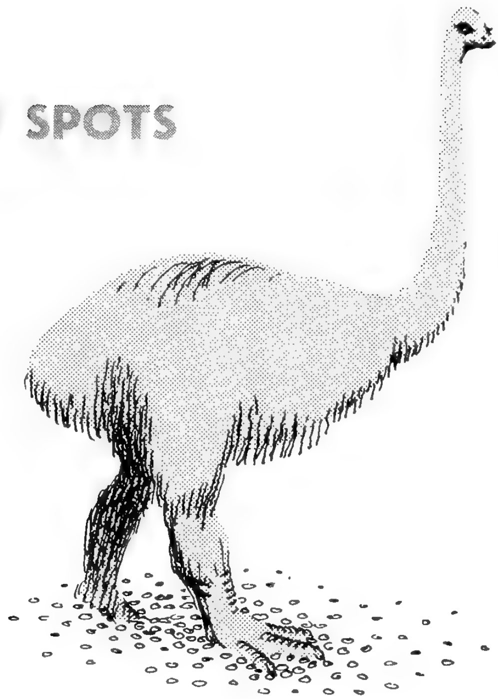
Memorial Hall is entered through the lobby from the South Entrance. In this hall are placed temporary exhibits of current interest. Many of these exhibits represent research in various departments of the Museum and recent results of exploration by Museum expeditions.

EXPLORATION AND GEOGRAPHY

Exhibits showing equipment of polar expeditions made in cooperation with the Museum are located in the corridor leading to the elevators.

Here are sledges with which PEARY (1909) and AMUNDSEN (1911) reached the North and South Poles respectively; also souvenirs of the AMUNDSEN-ELLSWORTH expeditions of 1925 and 1926. Maps of the Polar Regions show the routes of various explorers and the polar air flights.

MUSEUM HIGH SPOTS



RARE AND EXTINCT BIRDS – including reconstruction of the Dodo and a skeleton of the Mammoth Moa – in the Leonard C. Sanford Hall of the Biology of Birds, 1st floor.

MOA – reconstruction of this giant extinct bird, New Zealand Moa group – Whitney Memorial Hall of South Pacific Birds, 2nd floor.

ALASKA BROWN BEAR – largest bear in the world – Hall of North American Mammals, 1st floor.

"AN OCTOBER AFTERNOON NEAR STISSING MOUNTAIN" – strikingly realistic habitat group of the Pine Plains area of Dutchess County, N. Y. – Felix M. Warburg Memorial Hall, 1st floor.

METEORITES – one of the world's largest meteorites: the Ahnighito – 36½ tons – brought from Greenland in 1897 by Admiral Peary – American Museum-Hayden Planetarium, 1st floor.

DROP OF WATER – magnified a million times – depicted in a blown-glass model – Hall of Living Invertebrates – Gallery of the Hall of Ocean Life, 1st floor.

MEN OF THE MONTAÑA – the story of life in a Peruvian Rain Forest – authentic, recorded sound effects – Special Exhibition Hall, 2nd floor.

LITTLE DIOMEDE AND BIG DIOMEDE – islands in Bering Strait – International Boundary Line passes between them. Big Diomede is Russian, Little Diomede American – South Sea Birds, 2nd floor.

AFRICAN ELEPHANT HERD – Akeley African Hall, 2nd floor.

STONE HEAD OF OLMEC STYLE – Mexican and Central American Hall, 2nd floor.

THE "COPPER MAN" MUMMY AND SHRUNKEN HEADS – South American Indian Hall, 2nd floor.

MOTHS AND BUTTERFLIES – from all parts of the world – Insect Hall, 3rd floor.

DRAGON LIZARDS OF KOMODO – the world's largest living lizards – Reptile Hall, 3rd floor.

IVORY COLLECTION – African Ethnology Hall, 3rd floor.

TYRANNOSAURUS REX – king of dinosaurs – Cretaceous Dinosaur Hall, 4th floor.

BRONTOSAURUS – great plant-eating dinosaur – dinosaur footprints – Brontosaur Hall, 4th floor.

DINOSAUR EGGS – 60 MILLION YEARS OLD – from the Gobi Desert – Cretaceous Dinosaur Hall, 4th floor.

TOPAZ CRYSTAL – 600 POUNDS – largest in the world – Morgan Hall of Minerals and Gems, 4th floor.

WILD DOG GROUP – a hunting pack of African wild dogs looking across the plains – Akeley African Hall gallery, 3rd floor.

MUSEUM FACTS

The gross area of the American Museum is approximately 40 acres; of this, 23 acres are open to the public.

1,022,000 square feet of floor must be cleaned. It takes 125 men to do the job.

Electric mopping machines soap the floor, scrub it, rinse it and dry it.

One mopping machine does the work of eight men.

There are 58 halls open to the public, with a total of 2,302 exhibit cases.

The average exhibit case contains 68 square feet of glass. If all the glass in all the cases were spread out flat, it would cover an area of 3½ acres.

It takes two men to change the 31,000 light bulbs in use in the Museum.

The Museum contains 348 rooms, including offices, shops, meeting places, work rooms and laboratories.

PUBLIC INSTRUCTION

The week-day visitor to the American Museum will see eager groups of children standing with an instructor before various exhibits. Some of these groups may be classes with their own teachers but most of them will be part of the Department of Public Instruction's "World We Live In" program, designed for children of elementary school grades. Subjects or "themes" have been cooperatively planned with the school authorities.

The program, scheduled for each school day from 10:00 A.M. to 2:00 P.M., gives the children a complete day in the Museum, with subjects and teaching aimed at helping them to a more meaningful understanding of the world in which they live.

This is done with motion pictures, lessons in the halls, question and answer periods, physical demonstrations of principles or facts to be stressed and the actual handling of objects of natural science interest. If a group is studying Pan-America, for example, the children watch movies about Mexico, listen to Mexican music and even wear Mexican costumes and take part in dancing.

Special attention is given to classes or groups of children with visual and other physical handicaps. For full information, write or phone the Registrar, Department of Public Instruction, The American Museum of Natural History, New York 24, N. Y., Telephone, TRafalgar 3-1300, Extension 255.

LITTLE BOY WITH SWORDFISH.

SCHOOL CLASSES VISITING THE MUSEUM. Cooperating with the school authorities, the Museum offers a planned, full-day teaching program for school classes. The scene below, in the Museum's auditorium, shows a part of this program.

TEACHERS' COURSES

Each semester as many as five different courses for teachers-in-service are offered by the Department. These courses, designed to improve the educational use of Museum resources by City teachers, are accredited by the College of the City of New York and Hunter College and are approved In-Service courses of the Superintendent of Schools. For full information, write the Registrar.

NATURAL SCIENCE FOR THE LAYMAN

This course is given each semester and is a series of field trips to nearby localities. It gives adults a chance to become acquainted with plant and animal life and the important Man-Nature relationships. Service charge for the course is $1.00 per trip for non-Members and $.75 for Museum Members. For complete information, write or phone Miss Farida A. Wiley, Department of Public Instruction.

CAMP NATURE COUNSELLOR'S COURSE

This course is given each spring to increase the efficiency of group nature work in summer camps. Service charge is $10.00. Write or phone the Registrar.

STORY HOUR CLUB FOR PRE-SCHOOL CHILDREN

The Story Hour Club, offered several times each year, introduces pre-school children from 3½ to 5 years of age to natural science and museums. Visits to exhibition halls are held in conjunction with the telling of stories concerned with natural science. The service charge is $5.00 per series of ten story-hour sessions. For further information write or phone Miss Marguerite Ross, Department of Public Instruction.

FREE MOTION PICTURE PROGRAMS

Museum visitors are invited to attend free motion picture programs on natural science subjects. The Wednesday series runs throughout the year and begins at 3:30 P.M. The Saturday series is from October to May and begins at 2:00 P.M.

INDOOR TRAILS

Young visitors may get more than twelve different Indoor Trails at information desks. These question-and-answer games, to be played in the halls, are well-illustrated and contain much accurate scientific information. The Trails, pencil included, are for sale at a modest price. Answers may be checked at the information desks.

DIVISION OF CIRCULATING EXHIBITS

This collection of educational exhibits and specimens in the field of natural science is carried to schools for classroom use. Materials are

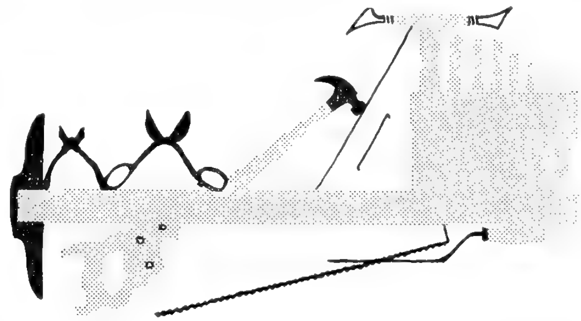
selected to meet subject requirements in science, social studies and related subjects. A fleet of Museum trucks services the schools on a regular schedule. For full information, write or phone the Supervisor of Circulating Exhibits.

ADVISORY SERVICES

On request, the Department provides advisory services on the educational use of museum resources. A model Nature Room is kept for the benefit of interested persons who wish to start one of their own in the classroom or in a small museum. This room is not open to the general public but may be seen, on advance request, on schoolday afternoons, after 2:00 P.M.

From a one-man lecture service, begun in 1884 by Albert S. Bickmore, the Department has expanded until over 10,000,000 persons are reached each year by its programs and services.

MAKING THE EXHIBITION HALL



The construction of the beautiful exhibits in The American Museum of Natural History is, in itself, as interesting as the viewing of them by the more than two million persons who visit the Museum annually. At the request of many visitors, we have included in the General Guide just what goes on before an exhibition hall is open to the public.

We will take the Felix M. Warburg Memorial Hall as an example. This hall depicts an area from early ages to the present, with all the interrelationships of environment, plant, animal and human life. Its method of presentation is a radical departure from the hitherto accepted method of museum exhibition.

First, the basic idea of the Hall is outlined in synopsis form. It is the complete story which the Hall will convey that the scientists think ought to be included in it, together with the emphasis they want made in the displays.

A committee of the Director, Board members, scientists and educational advisers studies the synopsis and passes on it. A lively discussion determines what can be added to make the exhibition as valuable as possible. The committee also decides on the location of the new Hall.

After the idea and the location are approved, the synopsis is analyzed from a display angle and the Assistant Director for Program Administration, together with his designers, draws up plans for the exhibits which are then submitted to the Director and his committee for approval. When the necessary funds are found, the work begins.

Metal workers, masons, electricians, carpenters and painters build the structures that will house the habitat groups, dioramas, models and

other kinds of display and the Department of Exhibition is working on the exhibits themselves.

As you enter the Warburg Memorial Hall from the 77th Street Foyer, you will note a large, eye-catching exhibit entitled "An October Afternoon Near Stissing Mountain." It shows the brilliant autumn coloring typical of this region, together with some animals found there. As an example of the building of the larger group, let us see how it was made.

Using sketches and Kodachromes made at the scene, the artist roughs out his picture on the curved background. Because there are no corners, the visitor is given a feeling of depth, perspective and reality that is not possible with a flat painted surface. After the sketch is rendered in charcoal, the artist fixes it with a shellac spray. Then, with fine oil pigments, he paints in the background of the group. He may employ as many as thirteen shades of blue in painting a sky from the horizon to the zenith.

One of the artist's difficult jobs is to make it appear as though the foreground objects continue into the vertical background. You will notice that he places clumps of red-leaved sumac against the background, then paints more sumac as though it grew beyond the real plants. When his careful color-matching and artistry are finished, the visitor has trouble telling where the foreground ends and the painted background begins.

If you look at the foreground, you will see that it is not flat, but rolling, as is the natural conformation of the land at this particular site near Stissing Mountain. This foreground, or terrain, is made by first determining the character of the actual ground, then cutting wooden forms or contours to match it. These forms are then covered with heavy wire netting, then burlap and plaster-of-paris, strong enough to hold up the weight of the men who are working on the group. This foreground is the foundation for the earth, plant and animal life in the exhibit.

ARTIST AT WORK ON BACKGROUND. Preliminary charcoal drawing.

While construction work and background painting are going on, the Department of Exhibition has been making accessories, exhibits, models and special effects for the Hall. Accessories include artificial leaves and flowers, trees, bushes, manufactured rocks, fruits, berries, preserved plants and mosses. At the same time, preparators are tanning skins, getting them ready to be mounted.

Some plants can be used as they grow in nature. Members of the pine family, mosses, and grasses are soaked in a solution of formaldehyde and glycerine. The glycerine prevents the plant from drying out and keeps it pliable. The formaldehyde preserves the material, but because it also tends to fade natural colors, the technicians must bring back the original hue by spraying with an air brush and lacquer of the right shade.

Clumps of grass are mounted on plaster-of-paris bases and sprayed with lacquer if the natural color is desired. In the group you may see some of this grass, each bunch standing close to the next, with earth patted down between the bases.

Most leaves are made by tracing the leaf pattern on a thick pad of crepe paper. The pattern is cut out with a fine-toothed band saw. Hundreds of leaves are turned out at one time by this method. An order may call for as many as ten thousand leaves. Each leaf must be handled separately after being cut out, as veins must be drawn or embossed, insect holes simulated and color applied to match the original. Even the midribs, of iron wire, are carefully tapered by dipping bundles of wire into nitric acid. The dripping-down of the acid thins the wires toward their ends.

Flowers may be molded from thin sheets of cellulose acetate, a non-inflammable plastic material. The acetate sheets are "limped" in a solution of acetone, placed in the mold where they take form, are removed, trimmed and delicately painted by hand. Even the tiniest pistils and stamens are painstakingly made so that the flowers will be as botanically accurate as possible.

There are no artificial rocks in "An October Afternoon Near Stissing Mountain." Artificial rocks are used when the real ones would be too heavy. Samples of real rocks and photographs of them help the technician to copy nature. He makes his rocks from wire netting, burlap, plaster-of-paris, papier mache and coloring materials. Should he be required to produce a "wet" rock, he runs shellac or varnish down the side and lets it dry.

In the "October Afternoon" group, you can see a red fox looking at a bluejay sitting in a canoe birch. The fox and the bird, as well as other small animals shown in the Hall, are mounted by putting their skins on artificial bodies made of wrapped excelsior.

There are no animals in the Warburg Memorial Hall that are mounted on hollow manikins. But this is such an interesting process that we have included it in our description. First, it must be understood that the Museum animals are not stuffed. The larger ones are mounted

on manikins, similar to those human forms found in the show windows of New York shops.

The manikin is begun by putting the animal's bones together on a wood and wire framework in the natural position desired, then patting sculptor's clay over the whole assembly. A statue is modelled by the sculptor, who is an expert animal anatomist. Making the statue is a long task and when the artist goes home at night or over the weekend, he wraps his work in woolen blankets, soaked with water. This keeps the clay fresh and impressionable. The statue is made as though the animal had just lost its skin — that is, the muscles, tendons, prominent veins and ribs are shaped in the clay so that they will show under the tanned skin when it is fitted to the manikin.

When the statue is finished and the skin has been tried on for size, the sculptor makes a plaster cast of it. When the cast is taken off, it is lined with overlapping strips of burlap. This rough fabric is coated with liquid plaster-of-paris, about as heavy as cream. When the plaster hardens in the burlap lining, the "shell" is removed, braced, put together,

TANNING A MAMMAL SKIN.

FITTING TANNED SKIN OVER MALE MULE DEER MANIKIN.

coated with a preservative and is now a manikin, waiting for the animal's skin.

Fitting the skin to the manikin is a delicate process. An adhesive is placed on the under side of the skin as it goes on the manikin. The skin is sewed up with needle and thread. The stitches do not show because they are on the under side.

To make sure that all the muscles, veins, ribs and hollows are prominent, the technician drives hundreds of small nails or pins through the skin into the manikin, to keep the skin tight around key points. When the adhesive is "set" in two or three days, the nails or pins are taken out. The animal now seems to have rippling muscles, his ribs show as they should, and even veins in his muzzle are as plain as they would be in a living specimen.

Good examples of such large mounts may be found in the Giant Eland Group or the Giant Sable Group in the Akeley African Hall on the second floor.

Now our background is painted, the terrain is covered with plants, the animals have been placed and the "October Afternoon Near Stissing Mountain" is complete. But the Department of Exhibition has been busy making many more displays for the Hall, other than the accessories for "An October Afternoon."

It has made farm buildings, farm machinery, small dioramas and cut-outs, mirrorscopes through which the visitor sees a remarkably realistic presentation of landscapes in many aspects, soil profiles, scientific models of root systems, apple blossoms, the hind leg of a bee with its pollen basket, the life history of the codling moth that attacks apples, studies of photosynthesis and respiration for the "Cycle of Nutrition

and Decay" and many other displays and models requiring scientific accuracy and infinite attention to detail and exact coloration.

The groups, displays and models have been checked by the Scientific Departments concerned. Geology advised how the mountains looked during various time periods, as shown in the displays "Geological History and Structure." The Department of Conservation advised on "The Water Cycle," "Soils and Soil Conservation," and "Life in the Soil."

Paleontology checked the accuracy of dioramas and objects that show the prehistoric plants and animals that lived in this place many thousands of years ago.

The Bird and Mammal Departments saw to it that the bluejay, the fox, the chipmunks, muskrat and other animals in the Hall were carefully installed in authentic positions and relationships.

The Department of Insects and Spiders supervised the placement of dragonflies, butterflies and beetles, to be found in "An October Afternoon," "From Field to Lake," and "Cycle of Nutrition and Decay."

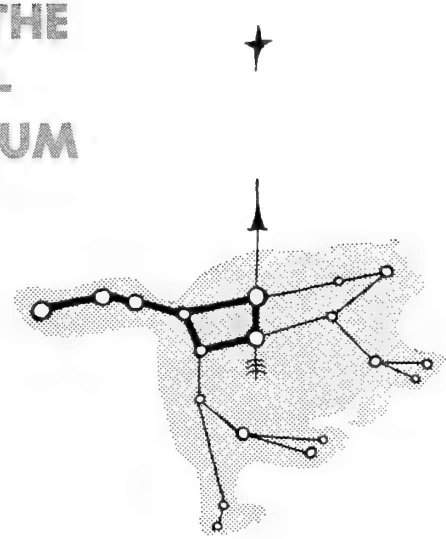
The Department of Amphibians and Reptiles and the Department of Fishes worked with the technicians and the preparators to insure the accuracy of the use of turtles, trout, catfish, perch and pickerel shown in "From Field to Lake."

The Department of Anthropology made its recommendations as to the best way to show man's part in this environmental exhibition. It checked on house and farm styles, tools, machinery, and agricultural methods of the various times depicted. All Scientific Departments concerned in the Hall helped in the writing of labels and other informative material.

At last the Felix M. Warburg Memorial Hall is completed. Into it has gone much of the Museum's time, money, talent and effort. The Director, Board members, advisory committees, the Scientific Staff, architects, exhibition personnel, artists, preparators, tanners, technicians, metal workers, masons, carpenters, painters, bookkeepers, public relations people, photographers, attendants – all have given of the best that is in them to make an exhibition hall of lasting beauty, scientific accuracy and educational importance.

For a description of these exhibits see the chapter entitled ECOLOGY AND CONSERVATION.

ASTRONOMY AND THE AMERICAN MUSEUM-HAYDEN PLANETARIUM



The American Museum-Hayden Planetarium, adjoining the Roosevelt Memorial, with its main entrance on 81st Street and Central Park West, constitutes the Museum's Department of Astronomy. Since the complete story of natural science begins with the story of the universe, it is fitting that the Planetarium's description begin the General Guide.

The establishment of the Planetarium in 1935 marked the culmination of a ten-year effort to secure for The American Museum of Natural History a planetarium projector. This complicated piece of precision equipment was developed for visual education and entertainment by the firm of Carl Zeiss at Jena, Germany, to present the fascinating and ever-changing drama of the skies.

In 1933 the Trustees of the American Museum formed a separate corporation under the Reconstruction Finance Corporation to construct and equip a planetarium. Mr. Charles Hayden, after whom the building is named, donated both the projection instrument and the Copernican planetarium on the first floor.

The high spot of the Planetarium is the great Zeiss projector, installed in a hemispherical dome 75 feet in diameter. The main body of the instrument is 12 feet long, with a large globe at either end containing projectors that show the fixed stars of the northern and southern sky on the inner surface of the dome. Individual projectors for the sun, moon and five naked-eye planets are mounted in the latticed cylinder that supports these globes.

Each of the large star globes contains sixteen separate lens systems in which are incorporated copper foil plates with holes of various sizes

for stars of different magnitudes, so that a central light source causes the star images to appear on the dome. These fit together in such a way as to reproduce the constellations exactly as seen in the real sky under ideal weather conditions. These projectors reveal images of all the fixed stars visible to the unaided eye from any part of the earth. Each of the thirty-two star field projectors is also provided with a device which automatically eclipses the star images when they are below the horizon.

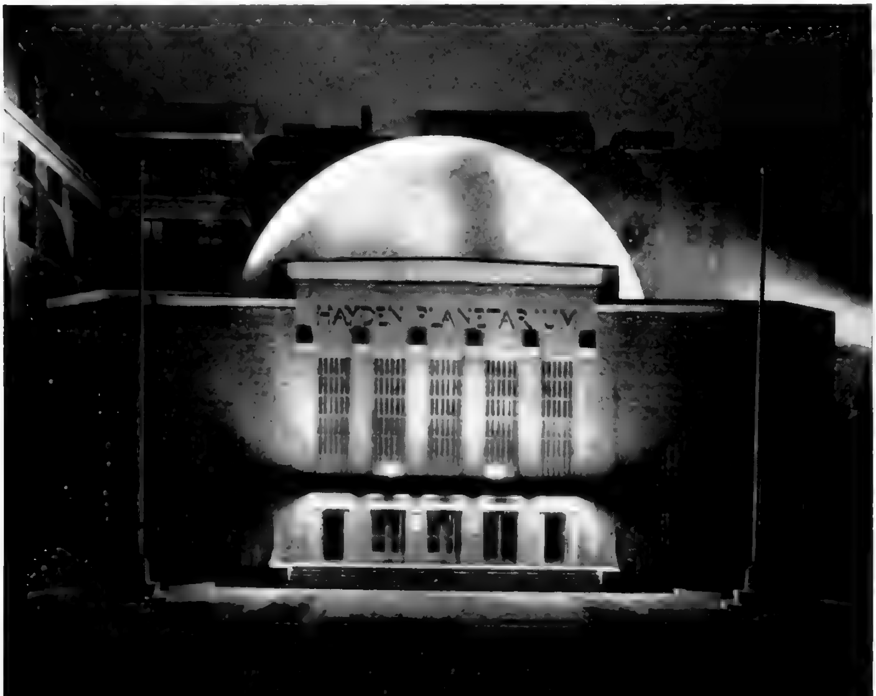
The projector also contains special instruments for projecting the Milky Way, comets, important variable stars and the various reference circles used by the astronomer in describing the positions and motions of the celestial bodies.

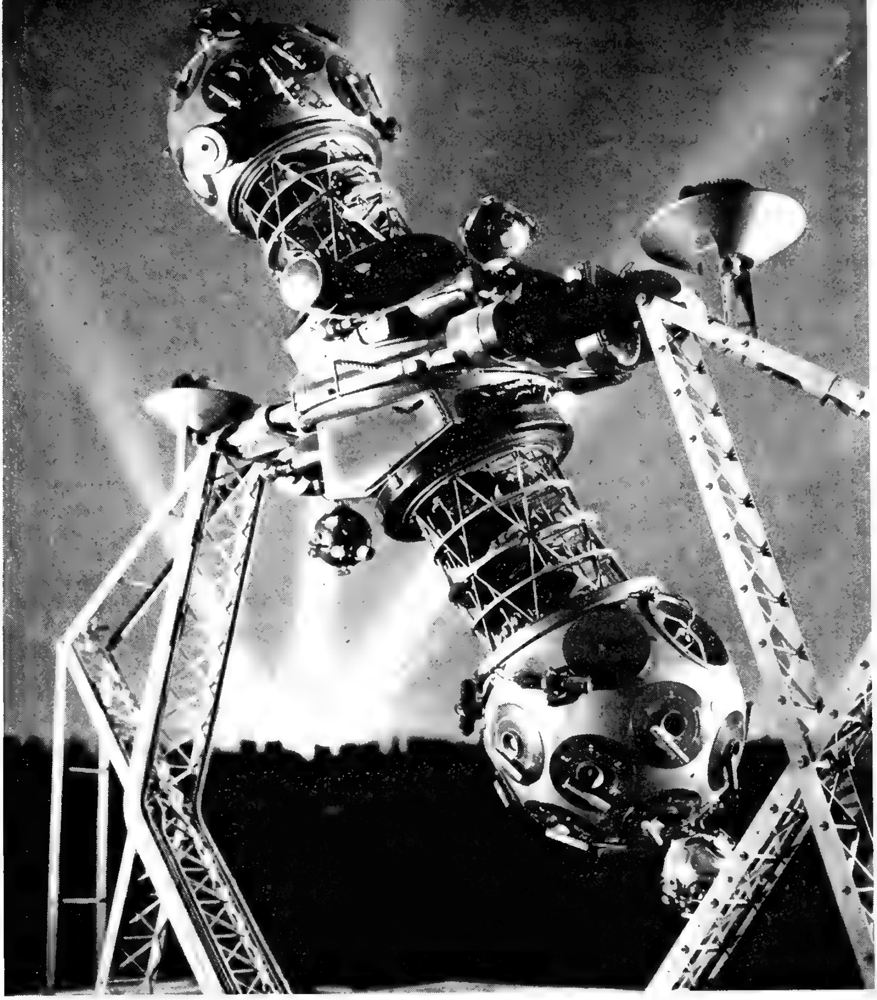
The main projector turns independently on any one of three axes. First, it may turn on an axis parallel with the polar axis of the earth. This simulates the apparent westward motion of the heavenly bodies due to the earth's rotation.

Second, it may rotate on an axis perpendicular to the plane on which the earth itself moves around the sun. The effect of this is to swing the north pole of the heavens around a circle that is completed every 25,800 years. This motion, known to the astronomer as "precession," introduces a long period of change in the sky picture. By its use, the Planetarium lecturer can set the instrument back some 5,000 years to 3,000 B.C. when Alpha Draconis, a dim star in the constellation of the Dragon, was our North Star. Or, by running the instrument ahead some 12,000 years, we see Vega marking the north pole of the heavens and the Southern Cross visible from the latitude of New York.

Third, the instrument may also be turned about an east-west axis to simulate the change that occurs in the sky picture as one changes latitude

MAIN ENTRANCE TO AMERICAN MUSEUM—HAYDEN PLANETARIUM.





THE ZEISS PROJECTOR OF THE PLANETARIUM.

on the earth. Thus, it may show the sky as seen from the North Pole, or, traveling south, one may see the Magellanic Clouds or the Southern Cross. Use of this motion enables the lecturer to carry his audience around the world in about five minutes.

The motions of the sun, moon and planets are effected through a complex arrangement of motors and gears so that they may be set in any position relative to the stars for any date and hour for many centuries backward or forward in time. This so-called annual motion also sets the moon at its proper phase for any given time.

The dome itself, upon which the stars are seen, is made of perforated steel, painted white on the inside, enclosed in an outer shell of copper. Under this great dome, the lecturer, with a complicated series of buttons, dials and switches to control, and with over two thousand possible combinations at his command, is virtually master of the universe.

A mere physical description of this amazingly complex instrument does not do justice to the breath-taking effect of a Planetarium showing. To the visitor, it seems as if the walls of the great domed room have disappeared, revealing the very depth and feeling of a star-studded sky as the unclouded night slowly falls.

The Planetarium projector does not bring the entire sweep of the sky story to the audience. Supplementary effects and techniques are constantly developed to widen the range of action. Horizon scenes, a rocket-ship interior, a swirling snow storm, eclipses, the radiance of northern lights, thunderstorms and a host of accessory effects are created. When combined with controlled lighting, music and special sound effects, the result is what has frequently been called the most dramatic of theatre productions.

Almost half a million persons visit the Planetarium each year to see such performances as "Rocket to the Moon," "The Beginning and the End of the World," "Color in the Sky," "The Conquest of Space," "Destination Saturn" and the Christmas show, "The Star of Bethlehem." There is usually a change of show theme on the first day of each month and demonstrations at scheduled times during the afternoons and evenings of every day in the year.

The Hall of the Sun is on the first floor. Suspended from the ceiling of this circular room, known as the Copernican Room, is a 48-foot model of the solar system in which the naked-eye planets are seen moving about the sun at their proper relative positions and speeds.

On the walls of this room are the constellations of the Zodiac whose stars, in luminous paint, seem to scintillate against the deep blue background of the night sky.

The actual demonstration begins in this room with a preliminary talk preparing the audience for the "sky show" in the dome on the second floor. The floor of the Hall of the Sun is enriched by a reproduction in terrazzo of the Aztec Calendar Stone. It was made by Victor Foscato and symbolizes the sun which was to the Aztecs the most important of the heavenly bodies.

A fine collection of astronomical paintings hangs on the Planetarium walls. Opposite the main entrance on the first floor the visitor sees a large mural painting and two panels by Charles R. Knight, depicting many of the sky legends and myths of the American Indian. On the second floor are the astronomical paintings of the late Howard Russell Butler of Princeton. Perhaps his most striking canvases are the three eclipse subjects shown over the southeast entrance to the dome. They are lighted by a method devised by Mr. Butler which makes them appear as realistic transparencies rather than as opaque paintings. The first represents the eclipse of June 8, 1918, observed at Baker, Oregon; the second, that of September 10, 1923, at Lompoc, California; and the third, that of January 24, 1925, at Middletown, Connecticut.

Next to the eclipse paintings are seven large canvases of the hydrogen prominences on the sun. Two bizarre prominences, known as the "Eagle" and the "Heliosaurus," are shown. The latter's resemblance to a dinosaur suggested its name.

The Planetarium houses two of the world's finest meteorites: the Ahnighito, 36½ tons, and the Willamette, 15½ tons.

In the first floor corridor is an outstanding loan collection of sundials, compasses and astronomical instruments, covering a range from ancient Chinese instruments, through the elaborate metal instruments made in the middle centuries in France and in Germany, down to the very accurate compasses of modern navigation.

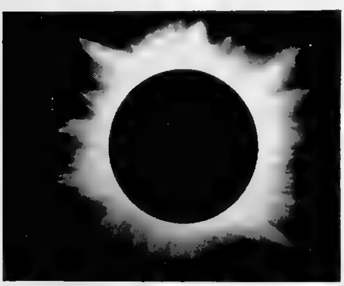
On the walls of the second floor may be seen large transparencies on glass, consisting of astronomical photographs from various observatories throughout the world. These include pictures of the sun and the moon, the planets, star-fields and star-clusters, gaseous, planetary and spiral nebulae, comets, meteors and meteor craters. Since many of them are time exposures, they reveal the celestial objects far better than they can be seen visually through the largest telescopes and show much detail that would otherwise escape the eye.

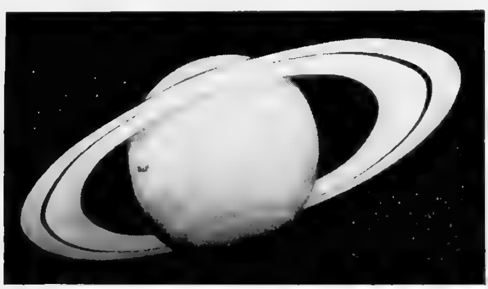
A striking exhibit of astronomical phenomena, painted in luminescent color activated by "black light," is in the corridor on the first floor. These fourteen murals, covering an area of 4,000 square feet, show in vivid detail such subjects as sun-spot activity, the Aurora Borealis, solar prominences, eclipses of the sun and the moon, galactic nebulae and our neighboring worlds, the planets.

Typical of the three-dimensional effect created by this recently developed technique is the mural of the Aurora Borealis. A curtain-type aurora is seen from the Arctic Circle where such displays reach their greatest brilliancy and color. Through moving light sources, the mural seems to shimmer as actual Northern Lights do.

Many of the wall cases have been given over to dioramas of the interior of the Mount Wilson Observatory, showing the 100-inch Hooker

TWO OF THE PLANETARIUM'S "BLACK LIGHT" MURALS. Left, corona observed during total eclipse of the Sun; right, the Planet Saturn.





Reflector; the 18th-century observatory at Jaipur, India; the ancient observatory at Peking, China: and Sir Isaac Newton's discovery that sunlight is composed of the colors of the spectrum. Another group of dioramas near the exit to the Roosevelt Memorial shows the various phases of weather, explaining such phenomena as the formation of rain, the action of a cold front and the mechanics of a hurricane.

Of constant interest to visitors are semi-permanent exhibits, as "The Time Capsule," "Your Weight on Other Worlds" and the "World Clock." Supplementary exhibits also include contemporary paintings, special blow-up photographs, models, maps, charts, books and instruments.

The combination of Planetarium projector and dome is ideal for instructional purposes and unique courses for laymen are given during the fall and spring seasons. Six courses in astronomy and navigation are offered to the public, with sessions held once a week during the evening hours. Special school-group showings provide supplementary background for studies in astronomy. Other instructed groups include West Point Cadets, U. S. Power Squadron units, engineering classes from nearby colleges, Scout groups and a variety of visiting convention groups. The Planetarium is also available for special lectures at hours when there are no regular performances.

The Book Corner is located near the main entrance to the Planetarium on the first floor. Here visitors may receive expert help in the choice of publications on astronomy, star identification, navigation and meteorology. Also available are seasonal star-charts, star-atlases, revolving star-finders, post cards, prints, astronomical gadgets, pamphlets, children's books designed to stimulate their interest in star-gazing and the "Sky Reporter," a monthly bulletin describing the current Planetarium demonstration, with sky maps and interesting information about celestial events.

Planetarium staff members are frequently called upon for explanations and advice about various astronomical, navigational, and meteorlogical problems. With the recent heightened public interest in sky phenomena, the Planetarium serves as a clearing house for information to the public via the press, radio and television.

Thus, by well-integrated programs and active participation in school and community functions, the American Museum-Hayden Planetarium carries out its major purpose – that of helping the public to interpret for itself the vast body of scientific knowledge about astronomy and the allied sciences in terms of its own need and desire to understand the universe.

GEOLOGY AND PALEONTOLOGY

Geology is the study of the earth in its present condition and as it was in past ages, back to the time of its origin as a planet. It is concerned with the materials composing the minerals and rocks of the earth and with the forces that have shaped these rocks into mountains, hills, valleys, lakes, oceans and all other land forms that are so familiar to us. It deals with the sequence of rocks as they were formed on the earth, with the history of the earth as revealed by rock sequences and by the fossilized remains of life contained within the rocks. Finally, it is concerned with the history of life on the earth as shown by the study of fossils.

Thus, the inclusive science of geology is made up of varied separate sciences and these are often given distinct names, such as mineralogy for the study of minerals, petrology for the study of rocks, physiography or geomorphology for the study of land forms, structural geology for the study of earth structure, stratigraphy for the study of layered rocks, and paleontology for the study of ancient life on the earth.

The Department of Geology and Paleontology at The American Museum of Natural History is interested primarily with the two divisions of geology that are based mainly on Museum collections — paleontology and mineralogy — although other aspects of the sciences are given some attention. But since the work of the Museum is based to a large degree on specimens, it is in those fields of geology where specimens — fossils and minerals — are of particular importance that the work of the Department is concentrated.

The Museum has one of the great mineral collections of the world, and this collection is being studied and increased. The large fossil

collections are subdivided into several categories, each under the care and direction of one or more authorities in his special field, assisted by technicians. Thus there is a collection of invertebrates, one of fishes, one of amphibians and reptiles, and one of mammals. These collections form the core around which are built comprehensive programs of research, field studies, collecting activities, and exhibits. Thus, the exhibits are one of the end results of extended scientific work and it is only through active prosecution of basic studies upon collections and new materials that the exhibits are kept authoritative and up to date.

At the present time, the exhibits of this Department are being revised. Modern exhibits of geology and fossil invertebrates are planned for future installation.

Scientific Work of the Department of Geology and Paleontology

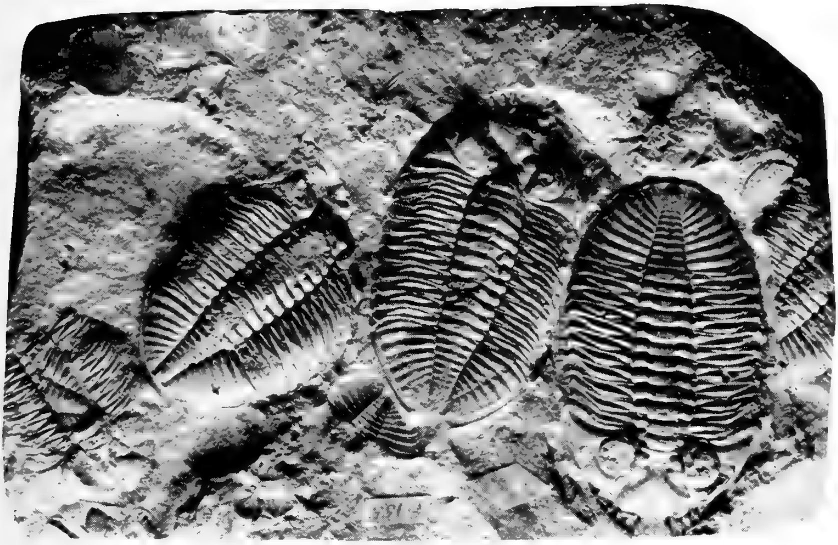
The scientific work of the Department is concentrated, at the present time, largely in the field of paleontology. Several programs of exploration and research are being carried forward, with the result that the collections of the Museum are being augmented and valuable new information is being published in technical papers, monographs, books and popular articles.

On death and burial, plant remains, and the shells and hard skeletons of mollusks, crustaceans and other invertebrates, are readily fossilized and preserved in the rocks. Indeed, many rock strata are largely composed of these fossil remains. Invertebrate remains are especially abundant in rocks that were formed as sediments in ancient seas which, at various times, covered almost all of the globe. Because of this abundance, invertebrate fossils occupy a favored place in deciphering the history of the earth and in the practical service of man.

The fossil invertebrates of each geologic epoch are distinctive, so that, in general, they serve as the principal standards for the classification and dating of rock strata, especially those of marine origin. This is of great practical importance in mining, quarrying and in the search for petroleum. Happenings in the development of the earth are referred to a standard geologic time scale which was founded on the paleontological record, especially that of the invertebrate fossils. The evolutionary history of these animals goes back more than a half billion years, to the Proterozoic era, well before the advent of the vertebrates and the land plants.

Very small invertebrate fossils, such as the skeletons of protozoans, are very commonly brought to the surface as oil wells are drilled, furnishing needed information on the relative position of each formation that is being penetrated, thus, in fact, guiding the drilling activity.

An active program of research in invertebrate paleontology, involving laboratory studies and field expeditions to various parts of the world, is being maintained. Studies in recent years have emphasized the important contribution that fossil invertebrates make in understanding ecological conditions of past seas early in geologic time. Recent investi-



TRILOBITES. Primitive crustaceans called trilobites were abundant in the early Paleozoic seas. These specimens *(Dalmanites)* were found in the Devonian rocks of New York State.

gations have centered around marine fossils of Permian age in South America and western Texas. Extended studies have been made of fossil organic reefs and their enclosed fossils in the Permian rocks of western Texas. This program includes comparative studies of modern coral reefs in the Bahama Islands and the South Pacific.

The fossil remains of animals with backbones are first found in rocks of Ordovician age, and they continue throughout the fossil record from that time until the present. These fossils record the evolutionary history of the vertebrates beginning with the fishes and ranging through the amphibians, reptiles, birds and mammals. Since the vertebrates have lived in many environments, their fossils are found in rocks formed from continental fresh-water sediments as well as from marine sediments.

Like the fossil invertebrates, the fossil vertebrates can be used for dating the rocks in which they occur, and in this respect they are of particular importance in the study of continental sediments, in which fossil invertebrates generally are not numerous.

The research program in fossil fishes currently involves the study of various groups of higher bony ray-finned fishes from the age of Dinosaurs and the early part of the Age of Mammals. One of the aims of this work is to obtain information on the history and relationships of the modern bony fishes. The Museum's fossil fish collection, which is one of the best of its kind, has an important role in these studies, and it is being improved constantly by Museum expeditions, exchanges with other institutions and gifts from all parts of the world.

The present research program on fossil amphibians and reptiles emphasizes the study of Triassic reptiles from various parts of the world. The purpose of this research schedule is to make known the animals that lived just before and during the early stages of the Age of Dinosaurs, a critical time in the evolution of reptiles. Extensive explorations have been carried on and collections made in the southwestern United States since the war, and much new material has been unearthed. In addition, field studies have been made in certain foreign countries.

In the field of fossil mammals, work is directed especially toward the collection and study of the primitive mammals that lived during early Tertiary times and of the advanced mammals that inhabited North America during the final phases of the Cenozoic era. Active collecting programs are being followed in the southwestern part of the United States for early Tertiary mammals, and in various sections of the west for the later mammals of the Cenozoic. Many fossils and new faunas have been found, to expand greatly our knowledge of the mammals that lived on the earth in former days. Much research is also being done on ancient South American mammals and on other problems of the evolution of this dominant group of animals.

All of this work on fossils reconstructs the history of life. It adds to our record of animals through time, and gives much new evidence for the interpretation of evolution. In addition, the research that is being carried on at this Museum is concerned with the former distribution and association of animals in the world, and the bearing that such information has upon the past relationships of continents and the history of climates.

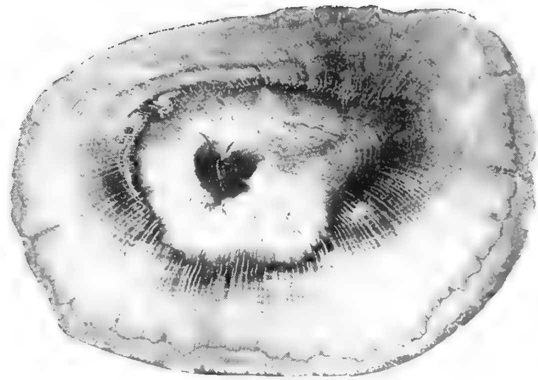
The history of life helps us to understand the origin, nature and destiny of man. Paleontology, as studied at this Museum, is concerned with concepts, and of these the concept of evolution is one of the most vital in our modern world. No single idea has revolutionized thought in modern times so much as the theory of organic evolution. And, in the study of evolution, the evidence and interpretation of fossils is of the utmost importance.

MINERALS AND GEMS

Minerals are nature's chemicals, and mineralogists have been able to recognize over 1700 different species. THE MORGAN HALL OF MINERALS AND GEMS is one of the outstanding collections of these minerals in America and, in fact, in the world today. Displayed here are many rare and unusual specimens, some of particular beauty. With few exceptions all of the known minerals are represented in this collection. Some minerals are so rare that only single examples exist, while many are so common that they are present almost everywhere in the earth's crust.

A study of the earth's crust shows that it consists of different kinds of rocks, a few of which have familiar names such as granite, marble, sandstone and slate. We see these rocks around us every day; they

OPALIZED WOOD. Opal is often found as the replacing material in fossil or petrified wood. Petrified wood is formed by ground water dissolving the woody matter from trees and simultaneously depositing silica. The fine texture of the original material has been preserved in this specimen from Lincoln County, Idaho.



form our mountains and canyons, and many of our buildings. On closer examination it is found that each rock is composed of individual substances which we call minerals. For example, a handful of sand from the seashore can be separated into various kinds of grains, and these grains frequently represent a variety of minerals. Each has definite properties of hardness, density, luster, color and transparency. These different kinds of substances, then, which nature has used to make up sand and the other materials of the earth's crust are called minerals. All of the various minerals may be classified on the basis of their chemical composition as shown in the accompanying table.

The primary task of the mineralogist is to understand the physical, chemical and historical aspects of the earth's crust. The science of mineralogy is, therefore, an integrated field of study related to geology on the one hand, and to physics and chemistry on the other. What does a professional mineralogist do? For example, if he wants to study a new mineral deposit, he first must have an understanding of the geologic setting in which the minerals are found, and he gains this by examining and mapping the rock formations in the field. Without this knowledge it would be impossible to speculate intelligently as to the origin of the deposit. Next, each mineral must be identified in the laboratory. Some minerals may be determined by inspection, whereas others yield their identity only through chemical tests or the measurement of optical constants by microscopic means, or in other ways. At times, the mineralogist may make x-ray diffraction patterns of his minerals, since a crystalline substance will give a regular pattern recorded on photographic film when subjected to x-rays. The intensity and positions of these lines are characteristic for each crystalline substance. He may, in addition, employ tools borrowed from the chemist and physicist, such as differential thermal analysis in which he subjects the mineral to a gradual rise in temperature, and observes the characteristic chemical changes which take place.

Or he may use spectrographic measurements which are useful in detecting minor elements which might be unnoticed by the usual qualitative chemical procedures. After all of the minerals of a deposit have been identified, the sequence of deposition can be worked out. Once this is known, the mineralogist can speculate as to the origin of the minerals and the nature of the conditions that gave rise to them.

All of the knowledge that the many mineralogists have gained after years of patient observation and study have been arranged in systematic form, and make up the science of mineralogy which may be outlined as follows.

Crystallography -- An important branch of mineralogy which is concerned with the internal arrangement of atoms and the external geometric forms exhibited by minerals.

Physical mineralogy — This includes a consideration of the various physical properties such as hardness, cleavage, color, specific gravity, magnetism, electrical properties, tenacity, as well as optical properties.

Chemical mineralogy — The various chemical properties, and also the origin and formation of minerals are considered. This includes chemical analysis, spectrographic techniques, x-ray fluorescence, and thermal analysis.

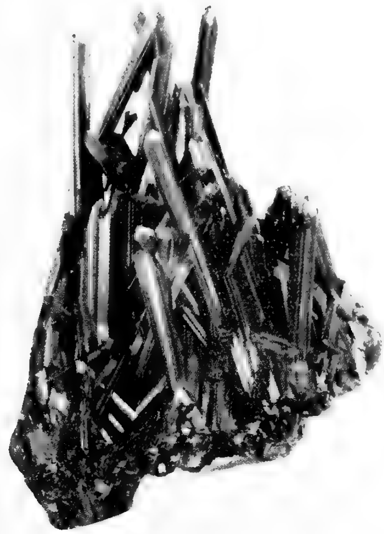
Descriptive mineralogy — This is a systematic listing of the various crystallographic, physical and chemical properties of minerals, and something of the environments in which they are found.

Determinative mineralogy — A classification of minerals based on physical properties and chemical composition which facilitates identification.

Mineral substances and products are indispensable to the welfare, health and standard of living of modern man, and are among the most valued and jealously guarded of the natural resources of a nation. The outstanding characteristic of the industrial era in which we live is the wide application of machinery and the use of power. In the last analysis

QUARTZ. This large crystal from St. Gotthard, Switzerland, has smaller crystals of quartz growing on its surface. Many minerals occur as inclusions in quartz, and in this case actinolite needles penetrate the quartz.

STIBNITE. Stibnite is a sulfide of the semi-metallic substance known as antimony. The slender orthorhombic prisms are made up of many crystals joined parallel to each other. The mineral is the chief source from which antimony is obtained. The specimen illustrated came from Inyo, Japan.



the significance of this civilization lies in the substitution of power machinery for animal muscle. This includes everything that has come to our generation through the steam engine, dynamo, automobile, airplane and telephone. The inventions have brought about the use of minerals in an ever-increasing quantity, and an ever-widening application. Thus, as industrial techniques have become more complex, minerals that contain metals with peculiarly distinctive properties such as aluminum, vanadium, tungsten, molybdenum, chromium, cobalt and nickel (previously of interest only in the laboratory) have assumed real economic importance. For example, platinum, in addition to its use in jewelry, is a necessary catalyst in sulphuric acid making, and acts as a key which unlocks a cheap process of chemical synthesis. Antimony is essential to the production of clear printing type metal, and mercury is a key metal in precise scientific instruments. All of the common materials used in modern building, such as steel, cement, brick, glass and plaster have their origin in minerals. The world demands more food, and as a result the phosphates, potash and nitrates bulk large in the commodities of commerce.

The methods of the mineralogist are used every day to solve practical problems such as the manufacture of abrasives, ceramics, refractories, synthetic crystals and steel. Mineralogy is an everyday tool with the mining geologist and should be for the prospector in order that he may identify properly the minerals which he finds. He must also know something of certain mineral associations, which are so characteristic that they may be important leads to the presence of others. Mineralogy has been of direct help in military operations.

Recently, the search for and study of radioactive minerals has become of great interest to mineralogists since these minerals form the basis for

future atomic energy. Clays are being investigated as a possible guide for the location of mineral deposits. Surprisingly enough, mineralogists are being of help to medical science. Since many parts of our body contain crystalline substances similar to minerals, they are capable of being studied by mineralogical techniques.

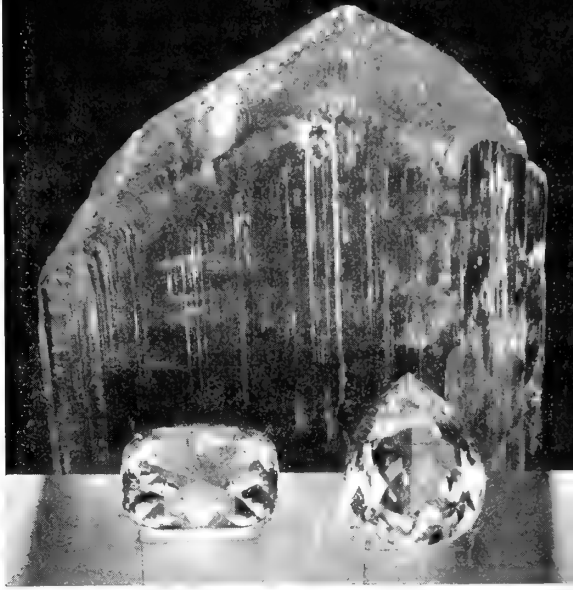
THE MORGAN MEMORIAL HALL OF MINERALS AND GEMS is, in general, arranged according to the chemical classification of minerals shown on the accompanying table. Specimens from all these groups are exhibited. The wall panel assemblage is a key exhibit to the large and more detailed collection in the flat cases occupying the remainder of the room, with the exception of the center aisle, which contains particularly fine specimens of gem minerals. As one progresses around the room, beginning with Panel A (at the left of the entrance) containing the native elements, it is evident that many of the minerals form regular solids with smooth faces which are characteristic of each mineral species. These regular forms are called crystals and are the external result of the unhampered growth and arrangement of the minute internal particles called atoms. The collection also has a number of fine wooden crystal models available for study. The recently acquired gold specimens from the William Boyce Thompson Collection are excellent examples of the crystallization of the native element gold. The sulphur crystals in Panel A are another good example of crystallization. Well developed crystals of the important iron mineral, hematite, are displayed in Panel M. There are several rare crystals of barite, one of the sulfates, and a barium mineral, in Panel AA.

Certain minerals among the many hundreds of different species are of particular value and we call them gems, because they appeal to our sense of beauty. The qualifications which make minerals gems include beauty of color, a certain degree of transparency that permits the color qualities to be developed by cutting and polishing, and sufficient hardness to preserve them against wear. In addition, the value of gems is governed largely by their rarity, together with a fluctuating unknown dictated by fashion.

The Morgan Collection contains several outstanding gems, including the De Long Star Ruby, and the "Star of India," the largest star sapphire in the world. There are also notable diamond crystals, as well as glass models of the world's famous diamonds, both in the natural state and after cutting. Several fine specimens of chrysoberyl are in the collection. Occasionally, this aluminate of beryllium contains hair-like inclusions arranged in parallel bundles, and when cut and polished is known as "oriental cat's eye." The specimen from Kandy, Ceylon, is thought to be one of the world's finest.

Two cases illustrating the geology and minerals of New York State are exhibited on the first floor of the Roosevelt Memorial. The characteristic minerals together with the localities are indicated.

KUNZITE. Kunzite is the clear lilac to pink-colored variety of spodumene. Crystals of kunzite are usually prismatic and flat. The locality from which this crystal and many gems come is Pala, San Diego County, California.



SILVER. This illustration shows a beautiful reticulated group of silver crystals from Kongsberg, Norway, a locality which has produced magnificent specimens of crystallized wire silver. Silver can be told from other silver-appearing minerals by its malleable nature, its silver-white color on a fresh surface, and its high specific gravity.

BARITE. These tabular crystals of barite on dolomite have come from Frizington, Cumberland, England. Barite, the chief source of barium, is used largely in the paint industry and to a lesser extent as a filler in paper and cloth, in cosmetics, and for barium meals in medical radiology.

Table of the Chemical Classification of Minerals

Elements — About 20 elements in an uncombined form are found as minerals, and are said to occur in the native state.

Example, gold, Au

Sulfides — These minerals consist principally of combinations of the various metals such as copper and lead with sulfur, selenium, or tellurium. The majority of the metallic ore minerals are in this class.

Example, galena, PbS

Sulfosalts — Minerals composed of lead, copper, or silver combined with sulfur and antimony, arsenic, or bismuth are included in this class.

Example, enargite, Cu_3AsS_4

Oxides — a. Anhydrous oxides. The minerals of this class contain a metal in combination with oxygen.

Example, hematite, Fe_2O_3

b. Hydrous oxides. The mineral oxides that contain water or the hydroxyl (OH) as an important radical are included in this class.

Example, diaspore, $Al_2O_3.H_2O$

Halides — This class includes the chlorides, fluorides, bromides, and iodides.

Example, fluorite, CaF_2

Carbonates — The minerals whose formulas include the carbonate radical, CO_3, are in this group.

Example, calcite, $CaCO_3$

Nitrates — The minerals in this class can be considered salts of nitric acid and contain the NO_3 radical.

Example, niter, KNO_3

Borates — The borates are salts of boric acid.

Example, borax, $Na_2B_4O_7.10H_2O$

Phosphates — Minerals whose formulas include the phosphate radical, PO_4, comprise this group.

Example, apatite, $Ca_5(F,Cl)(PO_4)_3$

Sulfates — Minerals whose formulas include the sulfate radical, SO_4 are in this class.

Example, barite, $BaSO_4$

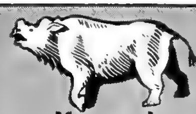
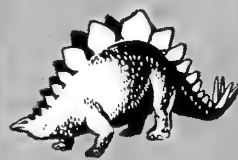
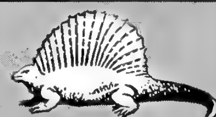
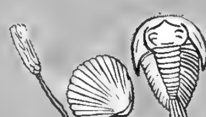
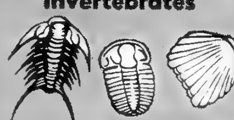
Tungstates — The few minerals whose formulas include the tungstate radical, WO_4, comprise this group.

Example, scheelite, $CaWO_4$

Silicates — The minerals included in this group form the largest class among minerals. They contain various elements, the most common of which are sodium, potassium, calcium, magnesium, aluminum, and iron, in combination with silicon and oxygen.

Example, quartz, SiO_2

TIME SCALE OF EARTH HISTORY

TIME SCALE	ERAS	DURATION OF PERIODS	PERIODS	EPOCHS	DOMINANT ANIMAL LIFE
	CENOZOIC 70 MILLION YEARS DURATION		Quaternary	Recent Pleistocene	Man
10 20 30 40 50 60 70		70	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	 Mammals
80 90 100	**MESOZOIC** 120 MILLION YEARS DURATION	50	Cretaceous		 Dinosaurs
150		35	Jurassic		
		35	Triassic		
200	**PALEOZOIC** 350 MILLION YEARS DURATION	25	Permian		 Primitive Reptiles
		20	Pennsylvanian		
250		30	Mississippian		
300		65	Devonian		 Amphibians
350		35	Silurian		 Fishes
400		75	Ordovician		 Invertebrates
450 500		90	Cambrian		
Figures in millions of years	PROTEROZOIC ARCHAEOZOIC	Figures in millions of years	1500 MILLION YEARS DURATION		BEGINNINGS OF LIFE

Only during the last 500,000,000 years have plants and animals produced hard parts capable of being fossilized. Here is a simplified chart of that quarter of the earth's history.

FIRST FOSSIL HALL — Fishes to Early Dinosaurs

Fossil Fish Alcove

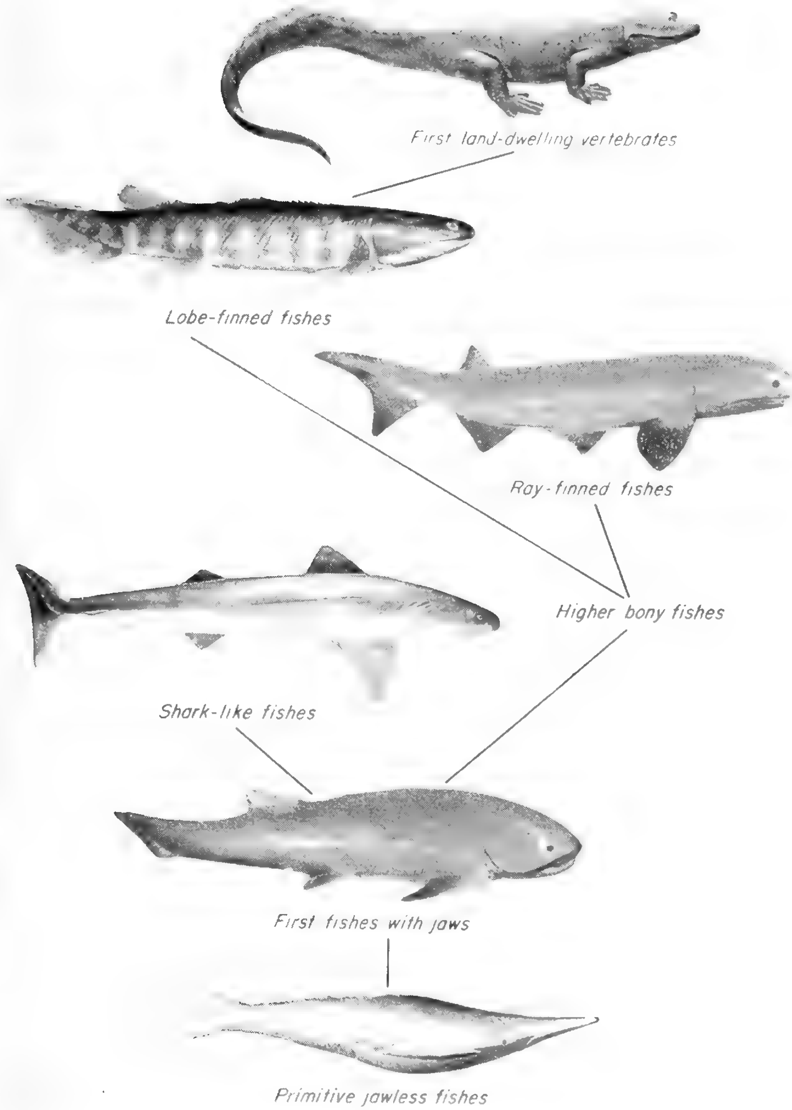
The known history of the fishes covers a time span of about 400 million years. During this long interval four main groups or classes of fishes were evolved. The first group, called ostracoderms, were jawless and had well developed bony armor. They were the ancestors of the living lampreys and hagfishes. Some time during the Silurian period, the ostracoderms gave rise to the second major category, the placoderms, which were the first fishes with jaws. The placoderms evolved into a number of distinct types, most of them with heavy, bony armor and mobile, paired fins. They were the first rulers of the Devonian lakes and seas.

The sharks and their relatives comprise the next main group of fishes. They evolved from primitive placoderms, probably in the Silurian, although the earliest remains of sharks are found in Devonian deposits. Early sharks and sharklike forms were numerous and varied during the Carboniferous or Coal Age. The group declined in the Permian and Triassic periods, becoming more successful again in the Jurassic with the rise of the types living today.

The fourth class includes all the higher bony fishes. This large and varied assemblage likewise had a placoderm origin, probably during the Silurian period. At the time of their first appearance in the fossil record, the bony fishes were already separable into two subclasses; the ray-finned forms that evolved into the common fishes of today, and the fishes with internal nostrils. The ray-finned types separated into numerous evolutionary lines before the Mesozoic era or Age of Dinosaurs. The fishes with internal nostrils included the crossopterygians and the dipnoans or lungfish. These earliest lung breathers were particularly numerous during the Devonian period. The crossopterygians are of great interest since they gave rise to the first land-living vertebrates. They are represented today by a single form, a fish called *Latimeria*, which lives in the coastal waters of South Africa. The lungfishes, once widely distributed, have persisted to the present time in South America, Africa and Australia.

The history of the fishes, as briefly summarized above, is illustrated in a series of simplified, synoptic exhibits in the Fossil Fish Alcove which is located at the west or far end of the First Fossil Hall. The visitor should walk in a counterclockwise direction within the Alcove when examining these exhibits, beginning with the family tree of the fishes which is to the right of the Alcove entrance.

Suspended above the entrance to the Alcove are the restored jaws of a Miocene fossil shark *(Carcharodon megalodon)*. The plaster jaws are modeled after those of a living relative and they support the actual fossil teeth. This giant shark, which is closely related to the modern white-shark or man-eater, attained an estimated length of 46 feet.



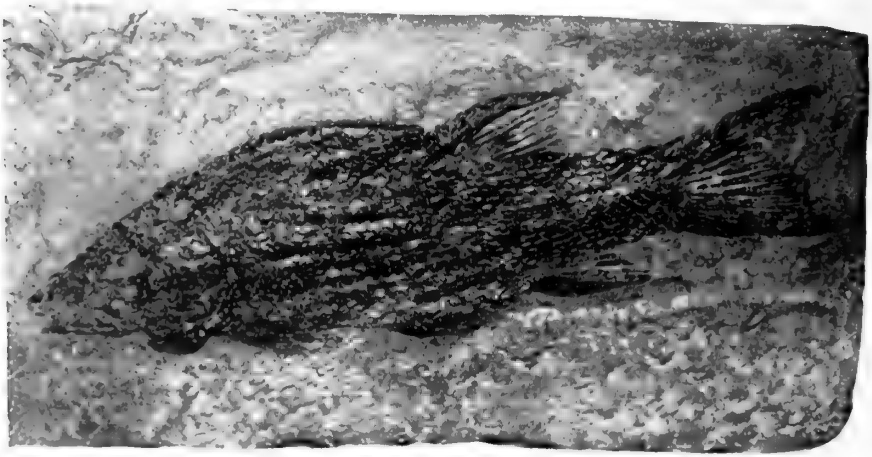
FAMILY TREE OF THE MAJOR GROUPS OF FISHES.

Inside the Alcove, is a simplified family tree of all the major groups of fishes discussed in the introductory paragraphs. It illustrates in graphic form the complexity of fish evolution and points out the relationships and classification of the major groups. If the visitor is interested in the details of fish evolution, it may prove helpful to refer to this tree from time to time while examining the other exhibits in order to note the relationship of a particular group to the others.

Moving from right to left, the next exhibit is devoted to the oldest known vertebrates the jawless fishes or ostracoderms. Typical examples of these ancient, armored forms are reconstructed in the models, while the cut-outs show some details of structure and variation in the form of the head armor. The ostracoderms include both bottom-dwellers and more active swimmers. In the left half of the same case are examples of the first jawed fishes, the placoderms. They existed in great variety during the Devonian period. The acanthodians were the most generalized types and they lasted into the Permian period. The others, which became extinct at the end of the Devonian, developed a variety of body shapes and elaborations of the bony armor. *Coccosteus* and his larger relative *Dinichthys* were predators; *Bothriolepis* and such types as *Lunaspis* were bottom-feeders. An actual skull of *Dinichthys* from Devonian beds near Cleveland is exhibited in a separate case. On the wall above the fire exit is a model of *Dinichthys* in the act of overtaking some primitive Devonian sharks *(Cladoselache)*.

The next case on the left illustrates the long history of the sharks and their distant relatives the chimaeroids or ratfishes. Because the shark skeleton is made of cartilage, which disintegrates rapidly, it is

A TRIASSIC RAY-FINNED FISH. ***Semionotus* was a probable ancestor of the modern gars.**



A GIANT CRETACEOUS TELEOST FISH. ***Portheus*** **lived in a large inland sea that covered much of central North America in late Cretaceous time. This specimen was discovered in the chalk beds of western Kansas.**

rarely fossilized. Under exceptional conditions, however, shark skeletons were preserved, and in one Devonian form *(Cladoselache)* even some muscle and kidney tissue was fossilized. Shark teeth, by contrast, are among the commonest of vertebrate fossils. Examples of the main types of teeth are displayed in this case. Fossil chimaeroids are known mostly from their teeth. The Paleozoic forms, called bradyodonts, had their teeth arranged as crushing plates and presumably they were mollusk eaters. The skull and some parts of the skeleton are preserved in the Carboniferous *Helodus.* The later chimaeroids, leading to the living marine *Chimaera,* are represented mostly by dental plates and spines.

The diorama represents a middle Devonian underwater lake scene about 300 million years ago. The fishes that swam in this lake are now preserved as fossils in the flagstones around Achanarras, Scotland, where they occur in considerable abundance. The models show the fishes as they appeared in life, although their coloring is, of course, hypothetical. The various types of fishes that lived together in this ancient lake — placoderms, primitive ray-finned forms, crossopterygians and lungfish —make up the fossil fish fauna of the Achanarras deposit. The vegetation, a simple aquatic plant or alga and submerged stems of the earliest land plants, also existed in middle Devonian time.

The exhibit to the right of the fire exit outlines the complex history of the bony ray-finned fishes or actinopterygians. This large and diverse group is usually divided into three subgroups which actually represent broad, successive stages of specialization. These subgroups are termed the chondrostean, holostean and teleostean, typified by the sturgeon, the gar and the perch. The primitive chondrosteans, of which the Devonian *Cheirolepis* is a good example, developed a number of evolutionary lines that independently reached the holostean level. Thus, such holosteans as the modern gar and bowfin *(Amia)* had a separate ancestry beginning some time late in the Paleozoic era. The teleosts, including the great majority of living fishes (herring, catfish, perch, halibut, etc.)

probably arose from a single ancestral stock in the Jurassic period. Since that time they have had an explosive evolution; there are more families of teleosts than in all the other major groups of fishes put together. On the wall above the shark exhibit is the fossil skeleton of a large Cretaceous teleost, *Portheus molossus*, from the chalk beds of Kansas.

The final exhibit, next to the Alcove entrance, considers the fishes with internal nostrils. The presence of internal nostrils indicates that these fishes came to the surface for air-breathing, and that they had true lungs in addition to gills. The central portion of the case shows the changes that occurred in the skull roof, the front or pectoral fin and the backbone during the transition from a primitive crossopterygian fish to an early land-living vertebrate or amphibian. This great event in vertebrate evolution took place in the Devonian period when seasonal droughts forced the crossopterygians to move over the dry stream beds in search of water and thus to explore the possibilities of land existence. The history of the coelacanth fishes, which arose from the Devonian crossopterygians, is illustrated on the right, ending in the living *Latimeria*. On the left are the fresh-water lungfishes or dipnoans, likewise descended from the Devonian crossopterygians. Both the coelacanths and the dipnoans evolved slowly, the modern representatives showing a marked resemblance to their ancestors.

Early Reptiles and Dinosaurs

The First Fossil Hall is dominated by the skeletons of three upper Jurassic dinosaurs, placed on a large island in the middle of the hall. The largest of the three skeletons, that of *Brontosaurus*, is almost seventy feet in length and is some eighteen feet high at the hips. In life *Brontosaurus* must have weighed thirty or forty tons. The aggressive, meat-eating dinosaur, *Allosaurus*, probably preyed upon the big, inoffensive plant-eaters such as *Brontosaurus*, and in this group *Allosaurus* is mounted as if feeding upon a brontosaur backbone. The third dinosaur in the group is the plated dinosaur, *Stegosaurus*, another plant-eating form.

A truly dramatic exhibit in this hall is the series of original brontosaur tracks, set into the base of the central dinosaur island. This track-way was excavated near Glen Rose, Texas, and reassembled in the Museum. In it are to be seen six forefoot and six hindfoot impressions made by a gigantic brontosaur as it tramped through a limy mud millions of years ago. The three-toed tracks of an allosaur follow those of the brontosaur, and since two of the allosaur tracks are super-imposed upon two of the large brontosaur tracks, it is evident that the meat-eating dinosaur was actually following the big plant-eater. Here, preserved in stone, is a story from the ancient geologic past!

The walls of the First Fossil Hall are decorated with mural drawings illustrating some of the animals that lived during the late Paleozoic and Mesozoic eras, The Age of Reptiles. Several assemblages of animals — or

faunas – are illustrated. These include the amphibians and reptiles that lived during the Permian times in what is now Texas, the Permian reptiles found in the Karroo desert of South Africa, the Chinle fauna of Triassic age from the southwestern part of the United States, the Morrison fauna that spread over western North America in the late Jurassic times, the Belly River fauna of western Canada, and the Lance fauna, the last of all dinosaurian faunas in North America. Also are shown various marine reptiles that lived during the Age of Reptiles, when dinosaurs ruled the land.

The exhibits in the wall cases of this hall are arranged in a sequence that begins at the west end of the hall, near the entrance to the Alcove of Fossil Fishes. On the left side of the doorway is a case illustrating the origin and evolution of the first land-living vertebrates, the amphibians. This exhibit shows how the amphibians arose from fishes and how they developed along several evolutionary lines, the most important of which is that of the labyrinthodont amphibians. In the labyrinthodonts of Permian times, as represented by *Eryops,* shown here by skulls and a skeleton, the amphibians reached the culmination of their evolutionary development and for a brief time were in active competition with the reptiles for dominance of the land. The last of the labyrinthodonts lived in the Triassic period and are exemplified by the large, flattened form, *Buettneria.* With the close of Triassic times the labyrinthodonts became extinct, but before dying out they gave rise to the frogs and toads. Various other amphibians were contemporaneous with the labyrinthodonts, such as the bizarre animals represented in this exhibit by the genus *Diplocaulus,* a flat creature with an excessively broad skull, shaped rather like an arrowhead.

In this case are also to be seen the first reptiles, derived from amphibian ancestors. The transition from the amphibians into the first reptiles was so gradual that it is difficult to draw a distinct line between the two classes of vertebrates. *Seymouria* is such a perfect intermediate form that the problem of whether it is properly an amphibian or a reptile is the subject of much scientific debate. A cast of the earliest known reptilian egg is seen as the central theme in this exhibit of the first reptiles; the original, in the Museum at Harvard University, was found in Permian sediments in north central Texas. Two primitive reptiles are exhibited in separate floor cases. One of these is *Diadectes,* from the Permian red beds of Texas; the other is *Scutosaurus,* from the Permian of northern Russia.

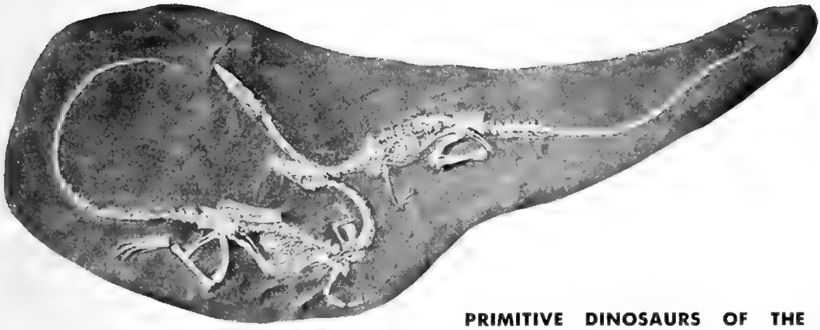
On the right side of the doorway leading to the Fossil Fish Alcove is an exhibit of mammal-like reptiles or therapsids from South Africa. These reptiles reached an advanced stage of evolution at an early date and some of them were directly ancestral to the mammals. In the center of the exhibit is a rare skeleton of one of the mammal-like reptiles, *Lycaenops.* Some therapsids developed along lines that were not directly ancestral to the mammals, but rather toward other areas of specialization.

The dicynodonts were large, plant-eating therapsids in which the teeth were suppressed except in the male animals, which had a pair of upper tusks in the skull. The dinocephalians were large therapsids, some of which were carnivorous and some herbivorous. A skeleton of *Moschops*, one of the plant-eating dinocephalians, is exhibited in a separate floor case.

Along the south wall of the hall, opposite the skeleton of *Allosaurus*, is a range of cases exhibiting pelycosaur reptiles from the Permian beds of Texas and Oklahoma. The pelycosaurs were related to the mammal-like reptiles of South Africa. They were frequently specialized in rather strange ways. For instance, the predaceous form, *Dimetrodon*, had a large sail on its back formed by an elongation of the spine of the vertebrae. *Edaphosaurus*, a water-dwelling, mollusk-eating pelycosaur, also had a huge sail on the back, in this case complicated by numerous bony cross-bars, like the yardarms on the mast of an old sailing vessel. The purpose of these sails is entirely a matter of conjecture. *Cotylorhynchus* was a large, heavy pelycosaur with a small skull.

Across the hall from the exhibit of Permian pelycosaurs is a series of cases in which are seen Triassic reptiles that lived during the early part of the Age of Dinosaurs. In the Triassic period reptiles other than dinosaurs were dominant, especially the large phytosaurs, of which a skeleton and some skulls are shown here. The phytosaurs, although they looked much like crocodiles, were not of crocodilian relationship. They preceded the crocodilians, and it was only after the phytosaurs became extinct, at the end of the Triassic period, that the crocodilians began their evolutionary development. The large slab of phytosaur bones exhibited in this case was found beneath the palisade cliffs of the Hudson River, about a half-mile south of the George Washington Bridge. Another fossil of local origin is the small skeleton of the primitive reptile *Hypsognathus*, discovered in a rock quarry between Clifton and Passaic New Jersey. *Hypsognathus* was the last of the cotylosaurian reptiles, and is related to some of the Permian cotylosaurs that are exhibited in the southwest corner of the hall.

A skeleton of a Triassic dinosaur, *Plateosaurus*, is displayed in a floor case near the wall cases just described. This specimen, from the upper Triassic sediments of Germany, represents a stage of evolution ancestral to the giant sauropod dinosaurs, such as *Brontosaurus*. Of particular importance in the study of dinosaurs are the skeletons of a primitive Triassic theropod, exhibited in the wall cases on the north wall and toward the east end of the hall. These skeletons, of the genus *Coelophysis*, were excavated several years ago at Ghost Ranch in New Mexico, and they are among the most complete dinosaur remains ever discovered. Numerous skeletons, complete to the smallest bones and fully articulated, were found at Ghost Ranch. These represent animals in various stages of growth, and together they give us detailed information about the primitive dinosaurs. In this same case is a family tree of the dinosaurs, illustrated by scale models.



PRIMITIVE DINOSAURS OF THE TRIASSIC PERIOD. The two skeletons of *Coelophysis,* exhibited as they were found in the rock, are among the most perfect dinosaur skeletons ever discovered. These dinosaurs were close to the ancestral stock from which later dinosaurs evolved.

Across the hall, on the south wall, is a case containing an exhibit of Morrison dinosaurs, contemporaneous with the skeletons that are displayed on the center island.

At the east end of the hall, on either side of the doorway that leads into the corridor, are exhibits that illustrate such topics as the means of locomotion, defense, method of feeding, and the geologic and geographic distribution of the dinosaurs.

In the corridor between the First and Second Fossil Halls are displayed marine reptiles that lived during the Age of Dinosaurs. Here are seen the fish-like ichthyosaurs, numerous in Jurassic and Cretaceous seas. A series of ichthyosaurs from Jurassic sediments in Germany show stages of growth. Also a mollusk-eating marine reptile, *Placodus,* is exhibited here, and in addition some plesiosaurs, the skeleton of a plesiosaur from the upper Jurassic of England. On the wall of the corridor opposite the entrance to this hall is the skeleton of a giant mosasaur of Cretaceous age. The mosasaurs were lizards that became adapted for swimming and developed to great size.

SECOND FOSSIL HALL — Late Dinosaurs

The Second Fossil Hall is devoted largely to the dinosaurs that lived during the Cretaceous period, immediately before the dinosaurs became extinct. Although other reptiles are exhibited in this hall, dinosaurs are dominant, as is evident from the large skeletons in the center of the hall and around the walls.

In the center of the hall are the skeletons of three large dinosaurs that lived together at the very end of Cretaceous times. These are

THE GIANT CARNIVOROUS DINOSAUR *(Tyrannosaurus)*. This late Cretaceous dinosaur was the largest of all land-living, meat-eating animals. It preyed upon other large dinosaurs.

Tyrannosaurus, the largest of the carnivorous or meat-eating dinosaurs and the largest flesh-eating animal ever to live on the land; *Triceratops*, a horned dinosaur that lived upon plants; and *Trachodon*, an aquatic dinosaur, also a plant-eater.

The skeleton of *Tyrannosaurus* is some 45 feet in length, and as mounted it stands about 20 feet high at the top of the head. The huge skull, armed with sharp teeth, is in a case on the floor where it can be seen near at hand; a plaster replica is placed on the skeleton. Skeletons of *Gorgosaurus*, a predatory dinosaur similar but not quite so specialized as *Tyrannosaurus*, are seen on either side of the doorway at the south end of the hall. At this end of the hall are displayed also the skeletons of *Ornithomimus*, a comparatively small and lightly-built theropod dinosaur, related in a general way to the large carnivors just described. *Ornithomimus* was adapted for swift running and for feeding upon fruits and small animals.

Trachodon is often called a "duck-billed" dinosaur because the front of the skull is flattened and expanded into a sort of bill. Because of this skull structure it is probable that *Trachodon* shoveled in the mud at the bottom of rivers and lakes for its food. There are various indications that this was an aquatic dinosaur, among them being a remarkable petrified mummy, displayed near the mounted skeletons, in which not only the bones but also the skin are preserved. This specimen shows that the skin in the duck-billed dinosaurs was of leathery texture, and that there were webs between the toes of the front feet, as might be expected in a swimming animal. Other members of this group represented in the hall by skeletons are *Corythosaurus*, *Saurolophus* and

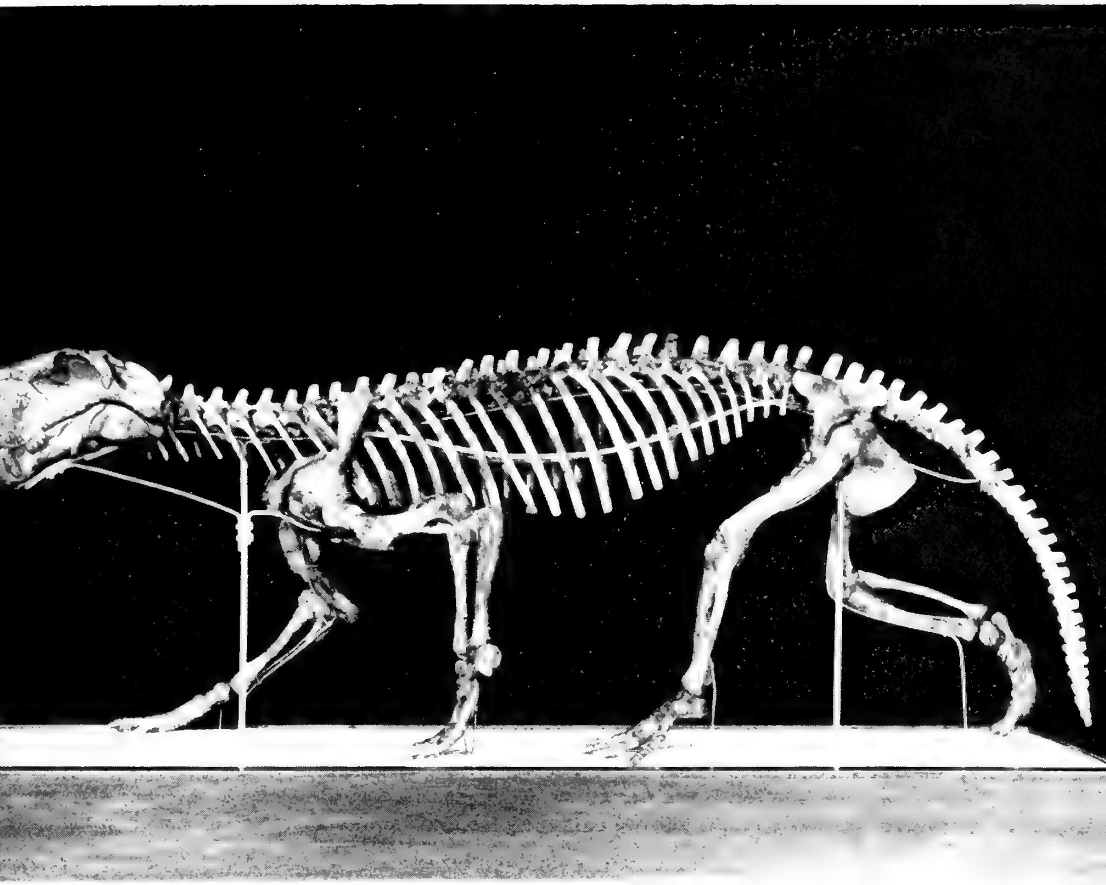
THE DUCK-BILLED DINOSAUR *(Trachodon)*. **These were water-living, plant-eating dinosaurs that used the flat, duck-like bill for gathering aquatic vegetation. They lived along the shores of rivers and lakes in late Cretaceous times.**

Procheneosaurus. Also there is a case showing the evolution of the skull in the duck-billed dinosaurs. Many of these reptiles developed large crests on the top of the skull, formed by an upgrowth of the premaxillary and nasal bones, and these contained extended loops of the nasal passages.

Related to the duck-billed dinosaurs were the peculiar troodonts or bone-headed dinosaurs, in which there was a great mass of bone above the brain. These animals reached the culmination of their evolution in *Pachycephalosaurus*, a skull of which is exhibited.

The horned dinosaurs, or ceratopsians, were plant-eaters, well adapted for defending themselves by fighting. They were something like rhinoceroses in the modern world. The skeleton of *Triceratops* shows the characteristic pose of a ceratopsian dinosaur, with the huge head lowered to present the three long, sharp horns at an adversary. These dinosaurs had a large frill on the back of the skull, which served in part as a protection for the neck and in part as an enlarged area of attachment for heavy jaw and neck muscles. Various horned dinosaurs other

DINOSAURS AND THEIR EGGS. ***Protoceratops* was a small, primitive horned dinosaur that lived in Mongolia during the Cretaceous period. The two skeletons are shown with a reconstructed nest of eggs.**



A MAMMAL-LIKE REPTILE FROM SOUTH AFRICA. ***Lycaenops*** **was a Permian reptile, belonging to the group of advanced reptiles that were ancestral to the first mammals. It exhibits many mammal-like characters in the skeleton.**

than *Triceratops* are on display, notably *Monoclonius*, with a single large horn on the nose and *Styracosaurus*, with spikes around the frill of the skull, in addition to the nasal horn. Of particular interest are the skeletons and eggs of *Protoceratops*, a small ceratopsian that was approximately ancestral to the larger types. The skeletons and eggs of *Protoceratops* were found at Djadochta in Outer Mongolia, by the Central Asiatic Expedition of this Museum. Several nests of eggs were discovered, and in some of the eggs are fossilized embryos of the dinosaur. These were the first dinosaur eggs to be discovered, and they confirmed previous speculations as to the method of reproduction in the dinosaurs.

One other group of dinosaurs, the armored dinosaurs, is exhibited in this hall by a skeleton of *Nodosaurus* with the body armor in place,

and by part of a skeleton of *Palaeoscincus.* These dinosaurs were completely covered on top by heavy bony armor that protected them against attack from the large carnivorous dinosaurs of the time.

On the left side of the doorway at the north end of the hall is a display of the pterosaurs or flying reptiles. These reptiles arose in Jurassic times, at about the time the birds were first evolving, and for some time they shared the skies with the early birds. There were many forms of flying reptiles, some of them as small as sparrows, others, like the giant *Pteranodon* on the wall, with a wing spread of twenty feet or more. In these reptiles the fourth finger of the hand was elongated for a wing support, and the wing itself was formed by a large fold of skin.

On the other side of the doorway from the pterosaur exhibit is a display outlining the evolution of birds.

THIRD FOSSIL HALL — Age of Mammals

The beginning of the Age of Mammals was characterized by a radical change in the kinds of vertebrate animals that inhabited the earth. The dinosaurs had disappeared at the end of the Cretaceous period, and with them the great swimming reptiles and the bizarre pterodactyls or flying reptiles. Although the mammals had already evolved from their reptilian ancestors by the Jurassic period, they did not begin to dominate the land until the beginning of the Tertiary period.

The Third Fossil Hall, located in the southeast tower area, has been designed to illustrate a number of topics that may be logically considered with the first part of the Age of Mammals. As the visitor enters this hall from the Second Fossil Hall, he will notice ahead of him a large semicircular exhibition case, the right part of which is devoted to the important question of why and how animals became extinct in the geologic past. The left part introduces the history of the mammals with a family tree showing the relationships of the various mammalian orders.

The reptiles that survived the Age of Dinosaurs include the crocodilians, the lizards and snakes and the turtles. These groups are considered in a series of synoptic exhibits along the corridor that leads from the Second to the Fourth Fossil Hall. Here are seen the skull of a late Cretaceous giant crocodile, *Phobosuchus,* from Texas and the shell and skeleton of a giant Pleistocene tortoise from India.

The story of the rise of the mammals begins with an exhibit on the origin of the mammals which is located beside the entrance to the Late Dinosaur Hall. Here the visitor may compare the skeleton of a reptile and a mammal, and note the differences in the method of reproduction of these two Classes of vertebrates as well as the differences in growth patterns. A series of models demonstrates the transformation of the skull and skeleton from reptile to mammal.

The next exhibit illustrates the first true mammals, which lived together during the Age of Dinosaurs. They are known mostly from fragmentary skulls and teeth. Together with actual specimens of these

first mammals, are enlarged models of lower jaws, skulls and teeth. These have been placed on a family tree to show how they were related to each other and to their later and more familiar descendants.

The marsupials are a well-defined group of mammals including the common opossum and the kangaroo. Their most distinctive character is the usual presence of a pouch on the belly of the female, in which the young, born at a very immature stage, are carried for some time after birth. There are also various characters in the skeleton that make it possible to distinguish the marsupials, fossil and living, from the great group of placental mammals to which man belongs. The exhibit on marsupials emphasizes the separate evolution of these animals into a variety of forms, many of which closely resemble various placental mammals. The marsupials were most successful in South America and particularly in Australia where they were for long periods not in direct competition with the placental mammals. In the adjoining case is a cast of the skeleton of *Diprotodon*, the largest known marsupial.

The placental mammals were not derived from the marsupials, although they and the marsupials had a common ancestor. The placentals multiplied and diversified rapidly in the Paleocene and particularly in the Eocene epochs. Quite distinctive assemblages existed in each of these periods along with characteristic plants and invertebrate animals, as shown by the exhibits that present cross-sections of early Tertiary life.

One such cross-section includes fishes of the early part of the Age of Mammals. Although little is known about the early evolution of the advanced bony fresh-water fishes, modern types are almost unknown in the fossil record until the Eocene period. Examples are exhibited of the various fossil fishes that occur in several large Eocene lake deposits in Wyoming, Colorado and Utah. In these lakes of 50 million years ago lived garfish, herrings, catfish and numerous other forms with close recent relatives.

Across the corridor is a series of skeletons of the first hoofed mammals or condylarths from the Paleocene and Eocene epochs. The long, low skull, short limbs and long tail were primitive characters shared for the most part with the earliest flesh-eating mammals. *Meniscotherium* was a small condylarth, about the size of a cat. *Ectoconus,* with its relatively small skull and heavy limbs had the dimensions of a large dog. *Phenacodus,* approaching the size of a tapir, represents the stock from which the odd-toed hoofed mammals (such as horses) probably arose.

SKELETON AND RESTORATION OF A PRIMITIVE HOOFED MAMMAL *(Ectoconus)*. This ancient mammal, from the Paleocene period, was quite generalized and apparently ate a variety of foods.


Skeletons of *Coryphodon* and *Uintatherium* represent two different groups of archaic hoofed mammals, descended from the primitive condylarths, that lived during the first part of the Age of Mammals. A family tree of these animals is displayed around the corner from the *Uintatherium* skeleton. In the semicircular end case is a skeleton of a Pliocene "earth pig" or aardvark *(Orycteropus).* Aardvarks are living today in Africa. The structure of the aardvark skeleton suggests that this curious animal may have evolved from the condylarths, although the skull is highly specialized.

Across the alcove from the family tree of the archaic ungulates is an exhibit concerned with the important subject of historical zoogeography. Here are explained some of the factors that have influenced the distribution of animals, particularly land mammals, in the geologic past — migration, the geographic isolation of groups of animals, their radiation from a point of origin and their sequence of arrival on a particular continent.

A general consideration of historical zoogeography naturally leads to an example of animal distribution and to the evolutionary effects of this distribution on the animals themselves. At the very beginning of the Age of Mammals, North and South America were connected by the Panama land bridge. At this time, three different groups of mammals crossed the bridge into South America: primitive marsupials, the ancestors of the armadillos and sloths, and one group of early hoofed mammals. Following this invasion, the land bridge sank beneath the sea and remained submerged until just before the beginning of the Ice Age, perhaps 3 million years ago. During this long period of isolation, the early immigrants into South America evolved along diverse lines. Across the corridor is a cast of the skeleton of *Macrauchenia,* a highly specialized descendant of the condylarth immigrants. This creature probably had a short elephant-like trunk which, together with its long neck and legs, must have presented a most bizarre appearance. In this section of the hall, the visitor can examine other mammals from South America. The notoungulates, evolved from the condylarths, were extremely varied, as the exhibits show. *Toxodon* lived in the Pliocene and Pleistocene epochs and, in build, must have resembled a short-legged rhinoceros. *Scarrittia,* from the Oligocene epoch, was a distant relative of *Toxodon.*

The edentates are a distinctive order of mostly South American mammals including the anteaters, armadillos and sloths. Grouped together in a dramatic manner in the tower alcove are some extinct descendants of the edentates that invaded South America during the Paleocene epoch. Included with them is the small Eocene *Metacheiromys,* a primitive edentate from North America. The ground sloths became common early in edentate history, and *Hapalops* is a typical Oligocene-Miocene form. *Megalocnus* got to Cuba by the Pleistocene. *Mylodon* and *Lestodon* were the giants of their kind, the former reaching North America after the land bridge was reestablished in the Pleistocene.

The armadillos were abundant and varied in South America by the Miocene. An early offshoot of the armadillo stock includes the glyptodons, which developed their protective armor into an immovable mass of solid, bony plates. By the Pliocene epoch they became very large, and in the Pleistocene epoch they migrated into Texas and across to Florida. *Glyptodon* and *Panochthus* are representative examples.

In the corridor near the Fourth Fossil Hall is an exhibit of the first flesh-eating mammals, or carnivores, called creodonts. The creodonts lived during the first part of the Age of Mammals and their remains have been found on all the continents except South America and Australia. Most of them had long, low skulls with a small braincase. In such forms as *Oxyaena,* the dentition was of the shearing type characteristic of later carnivores. The teeth of *Mesonyx,* on the other hand, had blunt, crushing cusps. The creodonts were the ancestors of all the later carnivores – the cats, hyaenas, civets, dogs, bears, racoons, mustelids, and also the seals and walruses.

The only placental mammals known from the Age of Dinosaurs belong to a group known as insectivores. These ancient placental mammals are exceedingly rare and of great value in evolutionary studies. Modern insectivores include the moles, shrews and hedgehogs. Certain Cretaceous members of this group, such as the tiny *Deltatheridium* from Mongolia, must be close to the ancestral stock from which all the other placental mammals arose. The skull of this form, which is the only part of the skeleton known, is exceedingly primitive and generalized for a placental mammal. A family tree of the insectivores is displayed in a case across the corridor from the creodont exhibit.

To the right of the insectivore exhibit are two unrelated groups of early mammals descended from the insectivores. The taeniodonts inhabited North America during the Paleocene and Eocene epochs. They had high, peg-like teeth and short skulls with deep, powerful lower jaws. The limbs were short and stout. The tillodonts are known only from the Eocene epoch in North America. The skull had a small braincase and the molar teeth were low-crowned; the skeleton was rather bear-like in its proportions.

To the left of the insectivore exhibit is a large panel presenting a synoptic tree of the primates, the order of mammals to which man belongs. The primates evolved from the insectivore stock at the beginning of the Paleocene epoch. During the Paleocene and Eocene the early primates were numerous and divided into a number of separate evolutionary lines. Many of these then became extinct, but some continued on through the Age of Mammals to produce lemurs, *Tarsius,* the New and Old World monkeys, the apes and, of course, man – all living today.

FOURTH FOSSIL HALL – AGE OF MAMMALS

Osborn Memorial

The fossil record for a few groups of mammals is unusually complete, and it is possible to follow evolutionary changes in the skeleton for

TITANOTHERES. These long-extinct relatives of the horses and rhinoceroses began as small animals about the size of a fox (*Eotitanops*, right, and *Brontops*, center). The last of the titanotheres, such as the gigantic *Brontotherium* (left), had large horn-like processes on the skull.

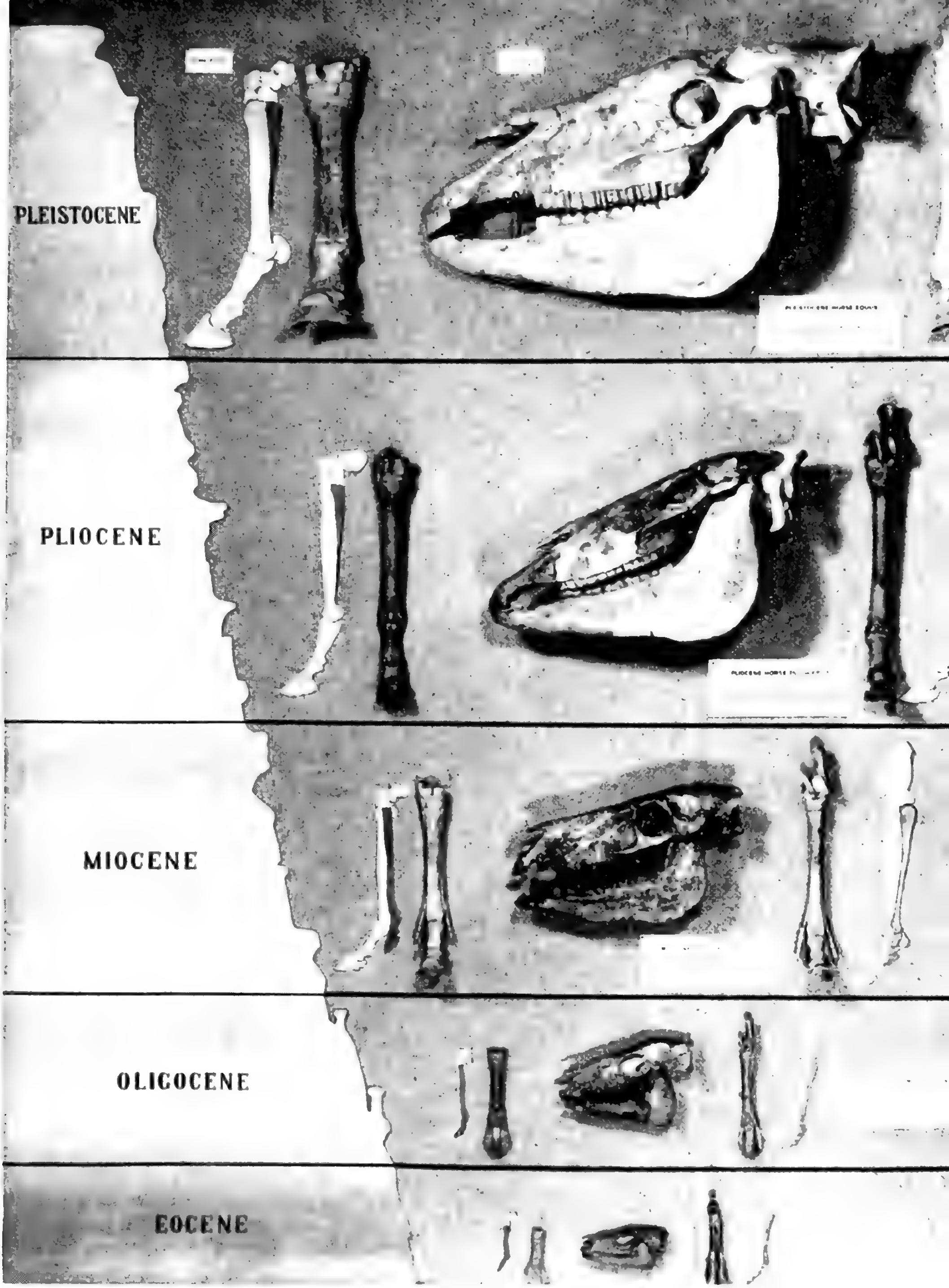
many millions of years. This hall is especially concerned with some of the better known records in the history of the placental mammals.

The south side of the hall illustrates the evolution of the various types of odd-toed ungulates or perissodactyls. Descended from the earliest hoofed mammals or condylarths, the perissodactyls were separated into the horses, rhinoceroses, tapirs and several now-extinct lines by the beginning of the Eocene epoch. One of the extinct groups, called titanotheres, existed only during the Eocene and Oligocene. As may be noted in the alcove beside the Third Fossil Hall entrance, they evolved in this relatively short span of time from the fox-sized *Eotitanops* to the gigantic *Brontotherium* with large, horn-like processes on its skull.

Another alcove is concerned with the extinct chalicotheres and the tapirs. *Moropus*, a skeleton of which is near the center of the hall, was a Miocene chalicothere. It had a long neck, shorter hind than front legs, and, most curious of all, claws instead of hoofs. A synoptic family tree of the perissodactyls is exhibited at the back of this alcove.

The rhinoceroses had a complicated fossil history and several distinct lines were evolved. *Hyrachyus* and *Hyracodon*, in the adjacent alcove, are examples of slimly built Eocene and Oligocene running rhinoceroses. *Amynodon* and particularly *Metamynodon*, represented by complete skeletons in separate cases, were short-legged, hippopotamus-like forms. *Trigonias* and *Teleoceras*, also in individual cases, were close to the ancestry of the living rhinoceroses. The large block of *Diceratherium* bones, including the skulls of twenty-one individuals, gives some conception of the enormous number of these animals that lived in Nebraska during the Miocene period.

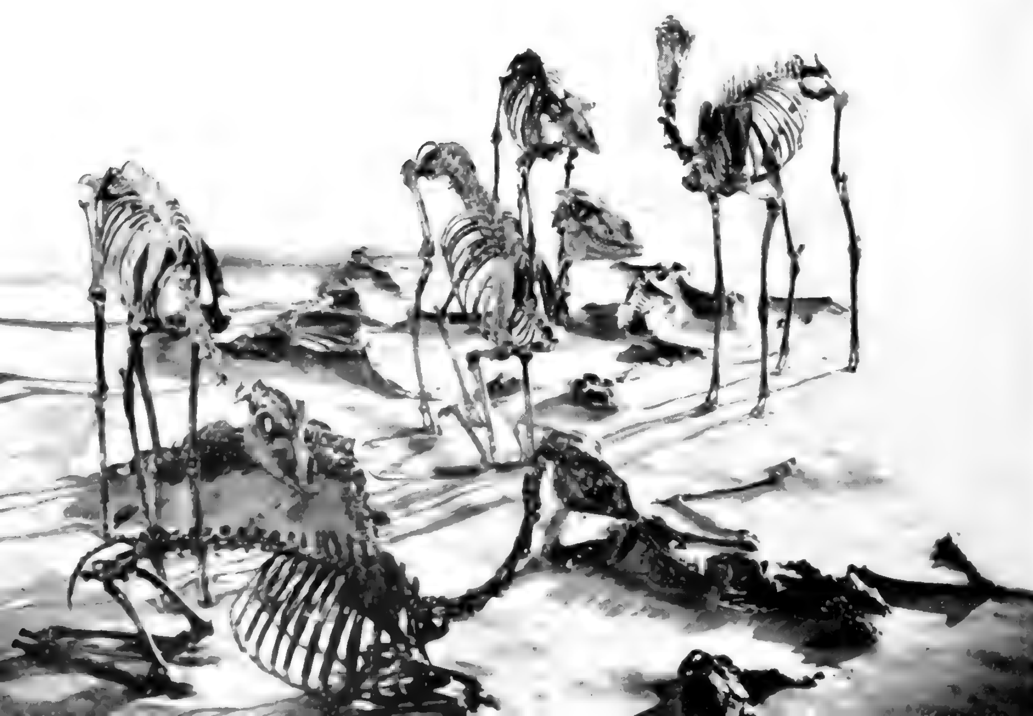
The history of the horses has long been of interest to students of evolution. The changes that occurred between the early Eocene *Hyracotherium-eohippus* and the modern horse can be traced with great



EVOLUTION OF THE HORSE. The important changes from the Eocene eohippus to the modern horse are illustrated here by the skull and feet.

MAMMALS OF THE UPPER PLIOCENE IN ARIZONA. In the foreground (left) is the large armadillo-like *Glypotherium* and (right) the single-toed horse *Plesippus.* Herds of the camel *Pliauchenia* and the mastodon called *Stegomastodon* are seen in the distance.

A GROUP OF MIOCENE CAMEL SKELETONS *(Stenomylus).* Some of these are mounted in characteristic attitudes as if they were alive, others are lying on the rock matrix as their remains were actually found by a Museum expedition. These camels inhabited America at the beginning of the Miocene period.



exactness because of the excellence of the horse fossil record. A series of progressively later horses demonstrates the reduction in the number of toes to the single functional toe of the modern forms. The lengthening of the limbs and the skull and the increase in general body size are well demonstrated.

Across the hall several alcoves are devoted to the many and varied even-toed ungulates or artiodactyls. The family tree of the artiodactyls shows the relationships of certain living members of the group (which includes the pigs, peccaries, hippopotami, camels, deer, giraffes, antelopes and cattle), and a few of the many fossil families. The artiodactyls, like the perissodactyls, evolved from the condylarths.

Perhaps the most successful artiodactyls of the Middle Tertiary in North America were the oreodonts. These rather pig-like ruminants were very abundant, particularly in the Oligocene and Miocene periods. The agriochoerids, represented by the skeleton of *Agriochoerus*, resembled the oreodonts except that the feet bore claws rather than hoofs.

The pigs of the Old World and the living peccaries of the New World had a long separate history. Skulls of typical examples of each group are shown.

Stenomylus was a small Miocene camel that lived in North America. The group in the center aisle is made up of skeletons of this creature as they were preserved in the rock, and in various living poses. The early evolution of the camels occurred in North America, and they did not enter South America (llamas) or Asia until near the end of the Age of Mammals.

The display of flesh-eating mammals or carnivores includes fossil representatives of the various types of cats, including the saber-tooth forms, and also the mustelids, bears, raccoons and dogs.

The rodents — squirrels, beavers, rats and mice, porcupines and guinea pigs and a host of other living and extinct forms — are the most successful and numerous of living mammals. The various types of fossil rodents known from the Eocene and Oligocene periods indicate that this group was subdivided into many evolutionary lines early in the Age of Mammals. The rather squirrel-like *Paramys* was a typical early rodent.

FIFTH FOSSIL HALL — Ice Age Mammals

The Pleistocene, or Ice-age, is one of the most interesting geological periods because it was during this comparatively short span of time that most of the evolution of man took place. The animals which lived then, sharing with early man the rigors of a glacial climate, were the most immediate ancestors of those we know today. In the Osborn Hall of the Age of Man are displayed many of the animals which are known to have been contemporaneous with early man. The murals on the walls, painted by Charles R. Knight, show groups of Pleistocene mammals of North and South America and Europe, and some of the early men associated with them.

Among the most spectacular of Pleistocene animals were the mastodons and mammoths, relatives of the modern elephants, remains of which are widely distributed over the earth. The evolution of these two distinct groups of the Proboscidea is shown here, beginning with the most primitive mastodons, on the right as the hall is entered from the elevators. These, the moeritheres, found in Egypt, were the smallest proboscideans, and had both upper and lower tusks and a short trunk or proboscis. Specimens in succeeding cases, from many parts of the world, show the gradual reduction of the lower tusks and number of teeth, the shortening of the front of the skull as the trunk lengthened, and the increase in size and bulk of the animal.

Three special exhibits, illustrated by skulls and jaws from the magnificent collections of Mr. Childs Frick, show (1), three widely different mastodon groups, based on the character of lower jaws and incisors; (2), the remarkable variation and specialization of the lower jaw symphysis and incisor within the so-called "longirostrine" group of mastodons; and (3), a life reconstruction on one side of a fossil skull and jaws of one of the longirostrines, *Ocalientinus,* showing the external appearance of the animal's head, cross-section of muscle and hide, and the bone itself.

Three mounted skeletons represent various stages in the evolution of the mastodon group: *Trilophodon*, from the lower Pliocene of Texas, is considerably larger than the moeritheres, but retains primitive features such as the elongated lower jaw and small lower tusks. *Megabelodon,* another long-jawed Pliocene mastodon, is not an ancestor of either the true mastodons or of the mammoths and elephants, but belongs to a distinct group of proboscideans. The skeleton which represents the American mastodon is here called "The Warren Mastodon," because of its interesting history. One of the most perfectly preserved fossil skeletons ever found, it was collected in 1845 from shell-marl beds on a farm near Newburgh, New York. After exhibition in New York and New England,

WOOLLY MAMMOTH. A herd of the woolly mammoths along the River Somme, France, during the last glacial stage.

RESTORATION OF RANCHO LA BREA TAR POOL SCENE. This painting includes the giant condor, saber-tooth cat, giant ground sloth, and in the distance, the Imperial Mammoth and the dire wolf.

PLEISTOCENE MAMMALS. Skeletons of the saber-tooth cat (left), dire wolf (right) and giant sloth (foreground, mostly submerged in tar) from the Pleistocene tar pools of Rancho La Brea, Los Angeles, California.

it was purchased by Dr. John Collins Warren, a professor of anatomy at Harvard College, was mounted in 1846 and seen by thousands of visitors. In 1849 it was remounted and placed on exhibition in the Warren Museum in Boston, where it remained until 1906, when J. Pierpont Morgan presented it, with the entire Warren Collection, to this museum. In 1907 the skeleton was taken apart, cleaned and remounted as it stands today. The American mastodon was the most abundant of the Pleistocene proboscideans of North America, especially in the forested regions east of the Mississippi.

The tall Columbian mammoth skeleton, with its great incurved tusks, is a dramatic example of the group of true elephants which co-existed with the mastodons in Pleistocene times. Mammoth skulls and jaws from many parts of the world, and one of the largest known mammoth tusks, over 16 feet in length, are exhibited here, with skulls of the living Indian and African elephants for comparison. Many remains of Pleistocene mammals have been discovered in the frozen ground of the far

north, often with flesh and hide well preserved. Examples of the dried flesh, wool and hair of a woolly mammoth found in Alaska may be seen here.

On the other side of the hall is a group showing how animals were trapped in natural asphalt pools at the famous Rancho la Brea tar pits in Los Angeles, California. Additional mounted skeletons of the saber-tooth tiger and wolf are displayed nearby. Here also is the huge European cave-bear, mounted in a standing attitude of attack. Pleistocene artiodactyls, or "even-toed" ungulates, include a series of skulls of various kinds of wild cattle and a mounted skeleton of a bison from Folsom, New Mexico, showing the association of arrow-points with bones of this animal. The mounted skeleton of the Irish deer, *Megaloceros*, with its wide antlers, is historically interesting in being the first mounted fossil skeleton exhibited in this museum. In contrast to this, is the skeleton of a pigmy hippopotamus which lived in Madagascar during Pleistocene times.

A small group showing one way in which fossil bones are preserved is the reproduction of part of the Conard Fissure locality in the Ozark Hills of northern Arkansas. During Pleistocene times, a fissure, or open crack caused by earth movements, was gradually filled with rocks, red clay and stalactites. Imbedded in this are found the bones of animals which inhabited the fissure, and of the prey they dragged into it. More than 60 different species of mammals, birds and reptiles have been found, mostly of a forest fauna such as bears, wild-cats, wolves, rodents, bats and snakes.

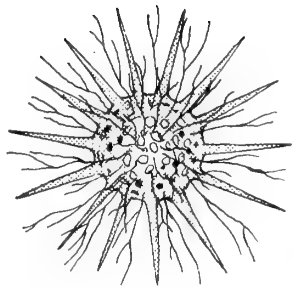
MICROPALEONTOLOGY

Micropaleontology is that phase of general paleontology that deals with very small animals and plants. The Department of Micropaleontology is wholly a research department and has no exhibits except for the models of *Foraminifera* displayed in the gallery of the Hall of Ocean Life.

The work of the Department includes research on the literature of the field, research on fossil material for clients, and independent work on microfossils. Studies are also carried on to determine the relationship of fossil and living forms to their past and present environments.

The results of these studies are largely contained in published material distributed to subscribing members of the Department. Among those subscribers are almost all of the larger universities and colleges, other museums and research institutions, and all the major oil companies of the world, whose principal output depends on a thorough knowledge of the tiny creatures that help us to find oil deposits.

INVERTEBRATES



The exhibits include a number of habitat groups showing invertebrates in their natural surroundings and a synoptic series from the simplest single-cell animals to the most complex invertebrates.

THE SYNOPTIC SERIES

Because of the small size and fragile nature of many invertebrates, a large part of this exhibit consists of glass or wax models, often much enlarged. These include the famous jewel-like creations of Herman Mueller.

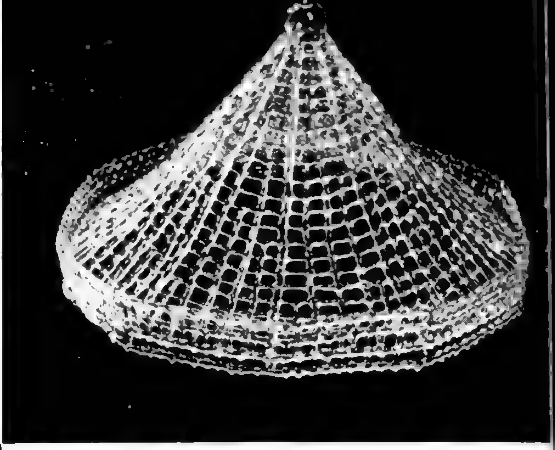
ONE-CELLED ANIMALS — *Protozoa.* These exhibits show the simplest form of animal life. Although in some forms the animals assemble into colonies, all are single-celled individuals. These exhibits are mainly models which represent protozoa enlarged hundreds of times.

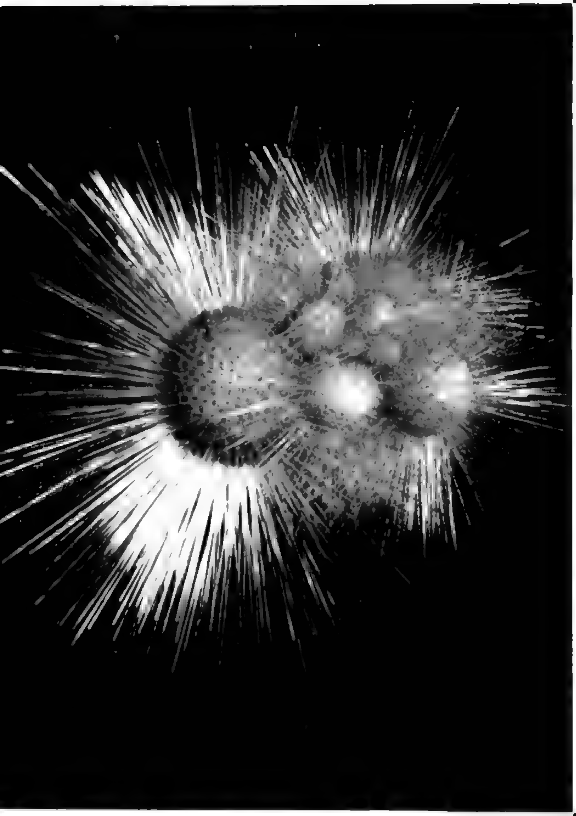
SPONGES — *Porifera.* Sponges are made up of many cells but these are comparatively loosely organized and do not form definite and distinct tissues as in the higher animals. Sponges range in size from small incrustations on stones and shells to the gigantic Neptune Goblets of Eastern Seas.

STINGING ANIMALS — *Coelenterates.* These include the coral animals and their relatives, the hydroids, jellyfish, sea anemones, sea fans, sea plumes, stony corals and similar creatures. The stinging animals have their cells organized into definite tissues but these do not form real organ systems as in the higher forms.

COMB JELLIES — *Ctenophora.* While similar in appearance to the stinging animals, these lack the stinging cells characteristic of the last group. Although they do not have definite organ systems, their organiza-

SETHOPHORMIS. This glass model shows the silica skeleton of a typical Radiolaria. These minute animals live in the deeper water of the seas.





GLOBIGERINA. This is a minute sea animal belonging to the group called Foraminifera. The needles are a floating device. The lime shells of the dead animals fall to the ocean bottom where they form, in certain areas, a muck called the Globigerina ooza. The fossil shells of these animals as well as the Radiolaria are important to the oil industry because they are used to date the ages of rocks.

CHAMBERED NAUTILUS. Cross section showing chambers. The animal occupies the last chamber.

tion is more complex than that of stinging animals. Transparent with iridescent, vibrating, swimming hairs, in life they are often objects of great beauty.

FLAT WORMS — *Platyhelminthes.* There are many important parasitic species of flatworms, including the tapeworm, which are shown in a series of models. The enlarged wax models of free-living forms show mostly species from the Mediterranean, but beautifully colored flatworms are found in almost all seas; those living in fresh water are usually less brilliant. All of the important organ systems of the higher animals are present in these worms.

ROUNDWORMS — *Nemathelminthes.* The parasitic roundworms are very widespread; almost every other type of many-celled plants and animals harbour one or more species of nematodes. Several serious human diseases such as trichinosis and elephantiasis are caused by these animals. Less well-known are the vast numbers of free-living nematodes found nearly everywhere in the soil and in both fresh and salt water.

ROTIFERS — *Rotifera.* The minute wheel animals or rotifers include many exquisite or grotesque forms. A few are parasitic but most are free-living. Most of them live in fresh water where they are very widely distributed. In addition to the comparative series of models of enlarged rotifers in the wall case at the southwest end of the gallery, rotifers in their natural environment are shown in the Pond Life Group at the other side of the Bahama Reef Group.

SPINY ANIMALS — *Echinodermata.* These include the sea stars, brittle stars, sea urchins, sea cucumbers and sea lilies. In spite of their entirely different appearance, many zoologists believe that this group of invertebrates is that which is most closely related to the chordates, the group of animals to which man belongs. This conclusion is based upon a study of the body chemistry and of the early stages in their life history.

CHORDATES — *Chordata.* The phylum includes not only the vertebrates but a number of small, relatively primitive and unfamiliar animals as well. The three cases devoted to this phylum in the Gallery of Living Invertebrates show the hemichordata and the ascidians. Anatomical models of important members of these groups show the details of their internal anatomy while other exhibits show the external appearance of many other forms.

PROBOSCIS WORMS — *Sipunculoidea and Echiuroidea.* These small groups of worm-like animals have until recently been included either in the segmented worms or combined into one group, the Gephyrea. Their anatomical peculiarities are, however, sufficienty distinct to justify considering them as separate groups. They are all marine and for the most part live either in burrows or in natural fissures.

1,000,000 TIMES MAGNIFIED DROP OF POND WATER. This exhibit shows Spirogyra with its spiral band of chlorophyll. In the center is the common pond weed, bladderwart, which bears bladders that trap small animals.

A PORTION OF THE ROCK POOL GROUP. On the rocky northern New England Coast are numerous basin-like crevices in the cliffs. At high tide, many of these are totally submerged, but as the water recedes they are left as stranded pools, richly populated with marine animals and plants. In this group, sea-anemones are disclosed among the rockweed, sea-lettuce and kelp.

SEGMENTED WORMS – *Annulata.* As typified by the common earthworm, these worms are made up of rings or segments. They include many remarkable and beautiful marine worms as well as the more familiar earthworms and leeches.

JOINT-LEGGED ANIMALS – *Arthropoda.* These include the crabs, lobsters, insects, spiders and their relatives. The number of living species in this group is greater than that of all the rest of the animal kingdom. The lobster exhibited here is one of the largest ever taken. The largest living arthropod is the Giant Japanese Spider Crab which is shown in the case at the north end of the gallery.

MOLLUSKS – *Mollusca.* The mollusca are next to the arthropods in the diversity and number of forms. They include clams, snails, slugs and limpets as well as squids and octopuses. All these animals have soft bodies but most of them secrete a hard exterior shell. The wall cases at the north end of the gallery contain a series of mollusk shells selected to show the range of size and form in each of the superfamilies. In the "A" case near the entrance to the hall are a group of large shells including a paper nautilus which is believed to be the largest perfect specimen.

Upon entering the hall, a large model of the GIANT SQUID, *Architeuthis princeps* is seen overhead. This model is based upon the studies made by Professor Verrill on specimens stranded in Newfoundland between 1872 and 1879. These large animals are attacked and eaten by the sperm whales. A fight between these two monsters of the sea is shown on the right in a mural painted by J. M. Guerry.

HABITAT GROUPS

On both sides of the hall at the far end of the gallery are displays showing invertebrates in their natural habitats. THE SALT MARSH GROUP is the first on the left. This group depicts the life in a salt marsh at Cold Spring Harbor, Long Island, and is typical of such marshes from Cape Cod to Cape Hatteras.

THE SOUND BOTTOM GROUP represents a sandy bottom with large granite boulders forming the reef known as the Devil's Bridge in Vineyard Sound, Massachusetts. The lobster and blue crab are among the animals shown.

THE WHARF PILE GROUP includes animals living in and among the submerged piles of an old wharf at Vineyard Haven, Massachusetts. The piles are covered with the flower-like colonies of sea anemones, hydroids and other stationary animals.

THE POND LIFE GROUP displays a cubic half inch of pond bottom enlarged one hundred diameters or cubically a million times, transforming a minute area into a forest peopled by rotifers and other strange creatures ordinarily invisible to the naked eye.

A PORTION OF THE BAHAMIAN REEF GROUP. Coral is a colony of animals that secrete a limey skeleton.

PEARL DIVERS GROUP. Tongareva Island. A great variety of coral is also represented in this group.

On the other side of the upper part of the Bahamian Reef Group a companion exhibit to the Pond Life Group shows two square inches of sea bottom enlarged to an area five feet square. Pieces of sea weed are seen encrusted with colonies of Bryozoa composed of thousands of small animals each of which has built a vase-like shell. Encrusting ascidians and their tadpole-like young, a sea spider and flower-like sea worms are among the other strange animals found here.

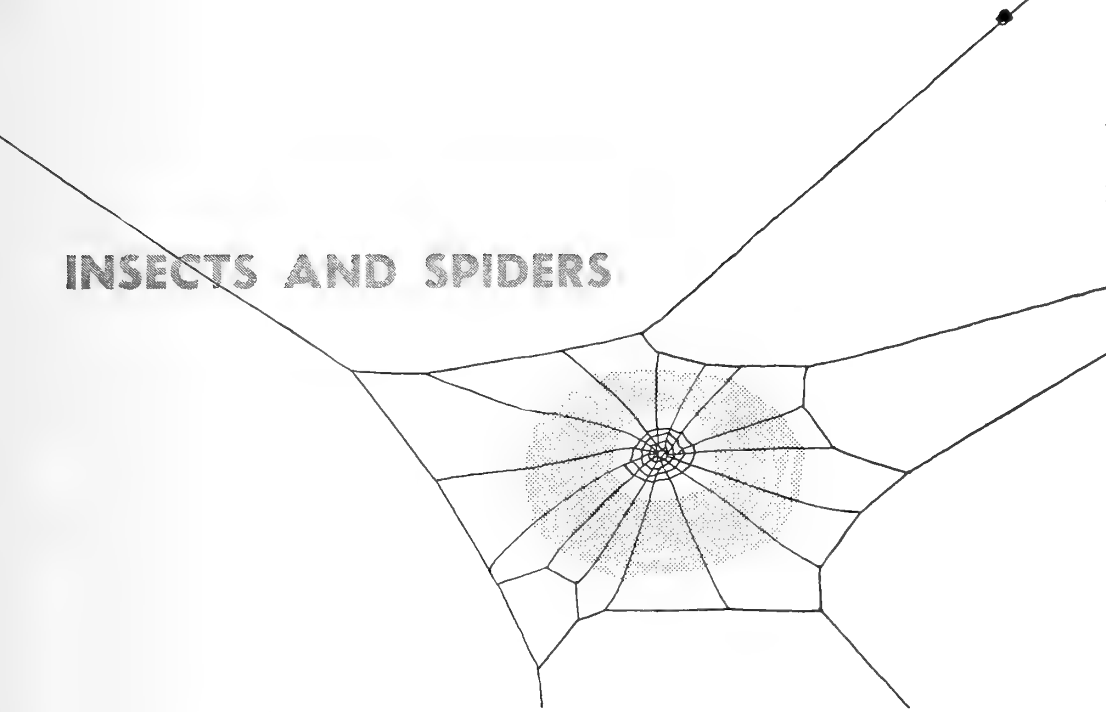
THE ROCK POOL GROUP contains the life which may be found in rock pools along our shores north of Cape Cod. In the scene, the falling tide has left a pool in a rocky basin which shelters a community of sea anemones, sea stars and other invertebrates.

THE EELGRASS GROUP shows a portion of the bottom of the harbor at Woods Hole, Massachusetts. In addition to the animals living on or above the bottom, a cross-section of the bottom reveals animals which burrow into the mud and sand.

THE BAHAMIAN REEF GROUP is seen at the farther end as you enter the Hall of Ocean Life. The portion of the group above the gallery shows the coral island and quiet lagoon. On the distant horizon the low-lying Bahama Island of Andros is seen with its fringe of coconut palms. Here the finest barrier reef in the West Indies parallels the shore. The small island in the foreground below the gallery depicts the coral forest as seen from the bottom of the sea. Many colorful inhabitants of the reef are seen among the branches of the tree-like elkhorn coral which rise to the water surface sixteen feet above.

THE PEARL DIVERS GROUP to the right of the Bahamian Reef Group represents a scene on the ocean floor within the enclosed lagoon of the coral atoll, Tongareva. This small, ring-shaped island, eleven miles in diameter, is in the South Pacific Ocean about 2000 miles south of Honolulu. This group shows the marked contrast between the brilliantly colored delicate ponds and finely divided clusters of coral found in the Pacific reef and the weird, branching species of the Atlantic exhibited in the adjoining Bahamian Reef Group.

INSECTS AND SPIDERS



Insects and spiders play a very important part in man's every day life, a part which is too often ignored or about which too little is understood by the general public. About 80% of the total number of species in the Animal Kingdom belong in the phylum Arthropoda which includes insects and spiders. At the present time approximately 850,000 species of insects and spiders have been described, and it is probable that there exists the almost unbelievable number of 9,000,000 additional species. Many insects and spiders have no direct bearing on man's economy or interests although they may be very important in maintaining a balance in nature. Because of this large number of species, it is, therefore, impossible to display examples of each.

In the Insect and Spider Hall, which is the largest and most complete exhibit of its kind in this country, examples of some of the more interesting species, and ecological and biological phenomena are presented. Beneficial and destructive insects are displayed, along with beautiful and bizarre insects from all over the world. These exhibits have been accomplished through the efforts of the research staff of the Department of Insects and Spiders, which is constantly studying many phases of insect and spider life. Problems in biology and ecology are always attracting the staff to work afield in many areas in this country and abroad where large and important collections are made.

Much of the work carried on in the laboratories at the Museum has to do with the classification or naming of the various species. The importance and necessity of this research work to the public arises from the fact that each year we receive thousands of requests for identifications of insects and spiders that have come to the public's attention. We are

constantly being asked to name a particular insect and to state whether or not it is dangerous, if it will destroy household furnishings, the home, personal belongings, or if it will affect the health of individuals coming in contact with it.

The visitor's interest in the Insect and Spider Hall will be affected by his own personal experience. The suburban dweller will perhaps be more interested in those insects affecting garden or ornamental plants, whereas the apartment house dweller who has no garden will probably be more interested in household insects. Exhibits of insects of interest to both groups are to be found in the Insect and Spider Hall.

Through the ages and even before the time of civilization, man has struggled with the insects for his existence. At the same time many insects contribute beneficially in supplying man with various commodities and many predaceous and parasitic species have aided in the control of destructive insects. The ways in which insects are beneficial to man are many and varied. Among these we might mention the silk worm in relation to true silk of commerce. Beeswax and honey are products of the honeybee which have long been used by man. Shellac is a secretion of a scale insect of India. The cochineal scale insect is used as a dye for artificial coloring of foods, drinks and cosmetics. A number of extracts of medicinal value have been made from the bodies of insects, and spider silk is employed in the manufacture of certain optical instruments. These are but a few of the examples of direct usage of insects. Probably the most important benefit derived from them is in their pollinizing of various fruits, seeds and vegetables which form a large portion of man's diet. Most of the animals used by man for his meat are dependent upon plants which would not exist if this pollinization were to cease. Even many of the fish products utilized by man would disappear were it not for the fact that aquatic insects are available as food for the fish. Many of our game birds are dependent almost entirely, or at least in large part, on insects for their food. In many parts of the world, from ancient times to the present day, insects have been eaten by human beings. Among these we might mention grasshoppers, crickets, beetles, caterpillars of moths and butterflies, termites and aquatic flies and bugs. Insects have also been used extensively in scientific research on genetics, physiology, psychology and sociology.

The ways in which insects are injurious to man are many and often of a critical nature. They injure or kill all kinds of crops, forest trees and valuable plants by chewing the foliage, sucking the sap, boring or tunneling into roots, stems or leaves, by carrying organisms such as fungi, bacteria, or protozoa which then attack the plant. It has been estimated that the direct annual agricultural losses occasioned by insects in the United States are about $2,000,000,000. They attack and annoy or kill living animals. Many species such as flies do direct damage by feeding on living tissue, others carry parasites of various diseases, some serve as intermediate hosts for organisms pathogenic to man and still others are venomous and are capable of causing bodily injury.

The species most commonly observed by the public are those which attack stored food products, clothing, books, furniture and buildings. Termites are among the most destructive in this group but such insects as powder post beetles and cigarette beetles do considerable damage to furnishings. The clothes moths and the carpet beetles do millions of dollars in damage annually to clothing and similar materials. The meal worms are often found in packaged cereals and other prepared grain foods and make such products unfit for human consumption. To this group can be added a host of species which attack field crops and upon which we are constantly required to apply expensive control measures. Among these pests we might mention the Colorado potato beetle, the Mexican bean beetle, the cotton boll weevil and the corn ear worm. No part of a plant is immune to insect attack. The immature stages of many species feed on the roots, whereas both immature and adult insects attack the leaves, stems, fruits and flowers.

Some of the greatest scourges in the history of mankind have been transmitted by insects. Black Death or Plague, which is transmitted by a flea, has claimed millions of lives since the sixth century and continues to be a constant menace to modern society. Yellow fever transmitted by the mosquito has at times made portions of the world uninhabitable and nearly prevented the construction of the Panama Canal. Malaria, also transmitted by the mosquito, has been and is an important disease of man. It is widely distributed throughout the world and during the recent war a considerable number of men had to be employed in the control and prevention of this disease. Typhus, transmitted by the body louse, has always been a major problem in congested areas and many thousands of people in many parts of the world suffer from its depredations. Ticks and mites, which are not insects but are related, carry a number of diseases which are of great importance. Rocky Mountain spotted fever which has claimed the lives of many people is carried by a tick. A number of species of mites are responsible for mange and almost everyone has come in contact with the red mites which make life miserable over extensive areas in the New World.

From the above account the reader will be impressed by the fact that very few organisms or habitats on the earth's surface are not frequented by insects. Indeed they have been more successful in adapting them-

THE HUMAN FLEA *(Pulex irritans)*, relatives of which are responsible for the transmission of Bubonic Plague.

selves to life on this world of ours than any other organism. Proof of this adaptability can be seen when one considers that insects came into being some 300,000,000 years ago and have out-lived such animals as the dinosaurs which might seem to have been better able to survive because of their size and strength.

THE EXHIBITS

The Museum visitor often wonders about the relationships between various groups of organisms. The Animal Kingdom is divided into a number of very large groups called Phyla. The insects, spiders and mites belong to the phylum Arthropoda. This phylum contains a number of classes including the Arachnida, or spiders and mites, and Insecta, or insects. In other words, the two groups belong to the same phylum but to two different classes within the phylum. The Insect and Spider Hall, therefore, covers members of two classes belonging to the phylum Arthropoda. Exhibits showing other classes in this phylum are presented in other halls in the Museum.

Because of the irregular architecture of the Insect and Spider Hall and the difficulty often experienced in locating particular exhibits, a map is presented to show the more important subjects and groups presented. It should be remembered, however, that there are many exhibits not indicated on the map and also that the cases are not numbered according to the map numbers. The numbers are referred to in the following text and the placement on the map is in the approximate location in the hall. Case 1 is to the left of the entrance from the Hall of Reptiles and Amphibia while Case 17 is to the left of the entrance coming from the Hall of Biology of Mammals.

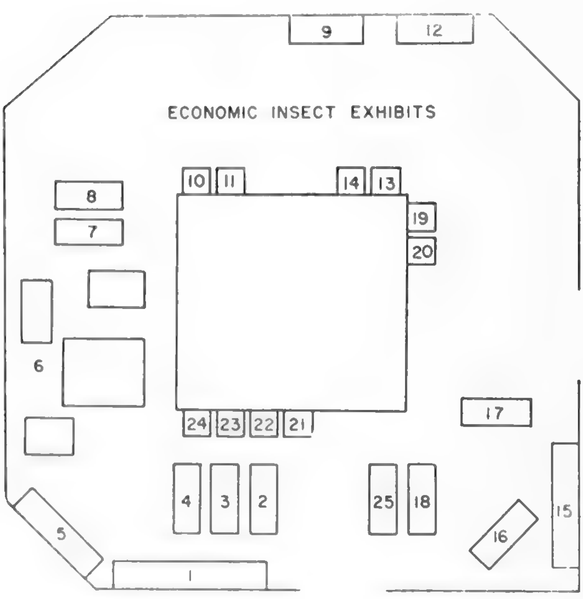


DIAGRAM OF THE HALL OF INSECT AND SPIDER LIFE showing the location of some of the more important and interesting exhibits referred to in the text.

BENEFICIAL INSECTS. Many insects and insect products have been and are utilized directly or indirectly by man. In Case 9 examples of the swarming of honeybees as well as the various types of cells contained in the hives are presented. Illustrations of the worker and queen and drone bees are also shown. Included in this exhibit is an example of the bee moth whose larva feeds at night on the wax of the combs.

Many different kinds of insects are used for fish bait and others are used as models for the construction of fishermen's "flies." Case 24 contains a series of models showing how to tie a fly, together with models of well-known commercial flies now in use. Examples of both American and English fishing flies are shown.

In Case 2 various examples of fruits, vegetables and other products whose development is dependent upon insects for pollination are presented.

A very extensive exhibit on the progressive stages in silk culture is shown in wall cases. This traces the development from the larval stage of the silk moth through the various stages in the manufacture of silk to the finished product. Examples of the adult silk moths and related moths with their pupal cases are also given.

DESTRUCTIVE INSECTS. On the south side of the hall in a number of cases are a series of exhibits showing insects that attack various types of plants and food products that are of value to man. Actual specimens and examples of types of injury are included. Such household pests as clothes moths, carpet beetles, cockroaches, house ants and bedbugs are presented either as actual specimens, or, where the insects are very small, as enlarged models or illustrations. Pests of stored food products including the flour moths, meal worms and tobacco beetles are to be found in these groups. Other insects attacking cotton, truck crops, fruits, woody plants, shade trees, nut trees and coniferous plants are to be found in this series.

One of the most destructive and most commonly encountered of the household insects is the termite. In Case 25 the visitor will find enlarged models showing the differences between the termite and the ant and in Case 4 a diagrammatic chart of the life history of the termite. Also in this case the visitor will find a series of enlarged models showing the various castes in the termite's social organization.

INSECTS AND ART. In Cases 10 and 11 are examples of art work in which insects are employed as subjects, or in which actual insect specimens or portions of their bodies are used in various types of ornamentation. Examples of such work from Asia, Central and South America are presented.

INSECT BIOLOGY AND ECOLOGY. The life history, habits of ants and their relation with other insects are presented by a series of illustrations and photographs in Case 3.

In Case 12, by means of colored illustrations and actual specimens, the growth and development of the Io moth is shown. Also in this case the visitor will find the immature stages and adults of the 17-year locust.

MODEL OF MOLE CRICKET (enlarged five diameters). An insect with forelegs especially adapted for digging.

Case 13 is a habitat group in which the Mole Cricket is shown in its natural environment in the ground.

Similarly in Case 14 a dragonfly nymph is shown in the act of catching a mosquito larva. Both of these exhibits depict the insects enlarged five times natural size.

Habitat group No. 21 shows a portion of a colony of Army ants with raiders bringing back insects they have captured and killed.

Case 22 is a similar exhibit showing leaf-cutting ants on branches, entering the nests, carrying the pieces of leaves that they have cut. These pieces of leaves are not eaten but are used in growing a special kind of fungus that is eaten as food.

Habitat group No. 23 shows a nest of the stingless bees with the entrance extending from a cavity in a tree. These bees are unable to sting and the honey of some species is pleasant to the human taste and is utilized by the inhabitants of many tropical countries.

An example of beetles in hibernation is presented in Case 20, showing the massing of Lady Bird beetles in a mountainous area.

The abundance of, and destruction caused by, the Japanese beetle is illustrated in Case 19.

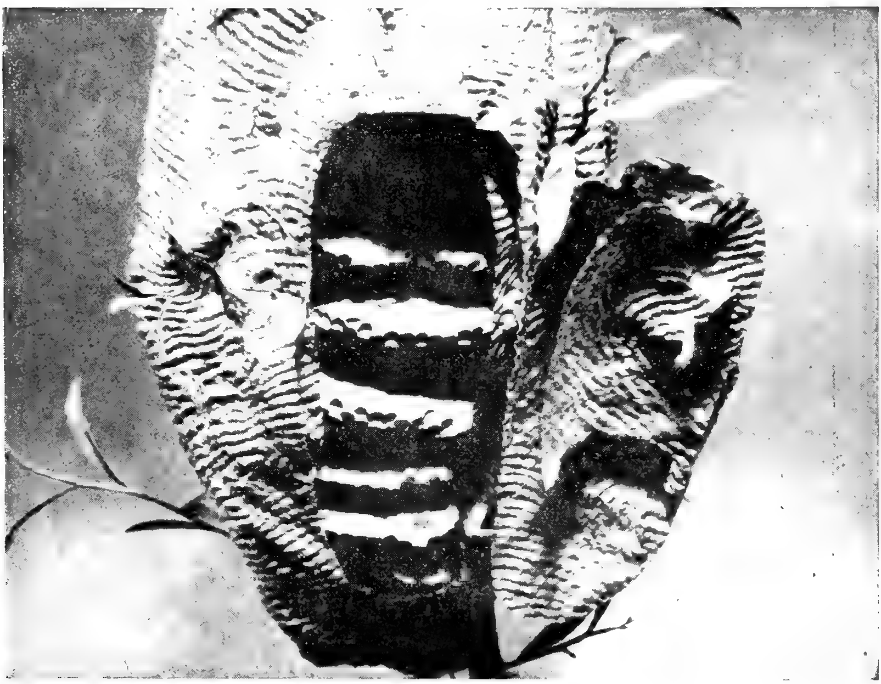
INSECT AND SPIDER ARCHITECTURE. Case 5, although incomplete, contains a number of examples of the different types of nests constructed by various species of tropical wasps.

Various types of ant nests are shown in Case 3.

In wall case No. 1 are models showing the processes in the weaving of the spider web. Pictures of actual webs, with colored illustrations of the spiders, are also to be found in this group.

DRAGON-FLY NYMPH catching a mosquito larva by means of its curiously modified lower lip which is segmented and has a pair of pincers at its tip.

TROPICAL WASP NEST with side cut away to show the internal architecture.



A GATHERING OF MONARCH BUTTERFLIES. In early autumn, the Monarch Butterfly *(Danaus plexippus)* assembles in great swarms in various sections of the United States. At nightfall, large numbers crowd onto the leaves and branches of trees and shrubs. These swarms move southward for the winter much as birds migrate. The females come north the next spring and re-establish the northern population.

BEAUTY IN THE INSECT WORLD. There is probably no group of organisms on the earth's surface in which can be found the combination, variety and brilliance of colors shown by insects. Case 15 presents many of the more beautiful butterflies and moths from various sections of the world. These are arranged around maps in which the areas of distribution represented by the moths and butterflies are variously colored.

Additional examples of many species of beautiful butterflies and moths from many parts of the world can be found in the cases surrounding the whale in the Hall of Biology of Mammals which is to the west of the Insect and Spider Hall.

ODDITIES IN INSECTS. A series of enlarged models in Case 16 illustrates the peculiar structures in the treehoppers and a series of models shows the complete life cycle of a local species.

In Case 17 the visitor can see actual specimens of insects showing the differences between the males and females of various species of beetles, moths and butterflies. Actual examples are also presented showing various types of special adaptation including the very long ovipositors in some wasps, the very long mouthparts in moths and the extensive wing development in the dragonfly which makes possible its very rapid flight. The phenomenon of variation is illustrated by actual examples in three species of insects.

Insects that mimic their environment are displayed in Case 18. Protective coloration as shown in some of the moths is presented, showing

THE BODY LOUSE
(Pediculus humanus corporis),
the carrier of Typhus fever.

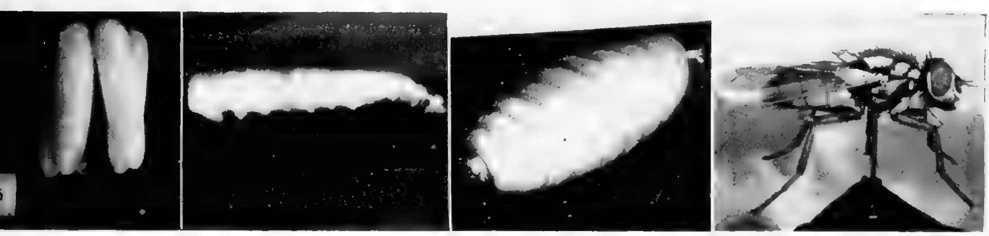
these insects in a portion of their actual environment. This exhibit also includes species that resemble dead twigs or leaves and others that look like fungus growths on tree trunks. A number of examples of mimicry — instances in which insects, commonly eaten by other organisms, resemble species that are not eaten and are probably distasteful — are presented. This case also includes a series of bizarre species. An example of a walking stick, one of the longest of all insects known, is on display with its wings extended. Various types of leg, antennal and mouthpart developments in beetles are shown by actual specimens.

INSECTS AND DISEASES OF MAN. It has been estimated that the annual vital loss to man and his domestic animals attributed to insects or diseases carried by insects is about $781,450,000. One of the most important diseases in the Western Hemisphere is malaria carried by the mosquito shown in exhibit No. 6. Shown are enlarged models of the egg, the egg raft, the larvae, the pupae and the adult and also a cross-section showing the internal anatomy of the adult. Descriptions of the various stages and comparisons with other species are given on the labels and by means of various diagrams.

Another disease that has been the scourge of mankind is yellow fever and the mosquito that is responsible for its transmission is shown in Case 7.

Typhus is a very important disease in congested areas and during

HOUSE-FLY *(Musca domestica)* showing four stages in its life cycle: eggs, larva, pupa and adult. This insect is responsible for the transmission of typhoid fever and filth diseases.



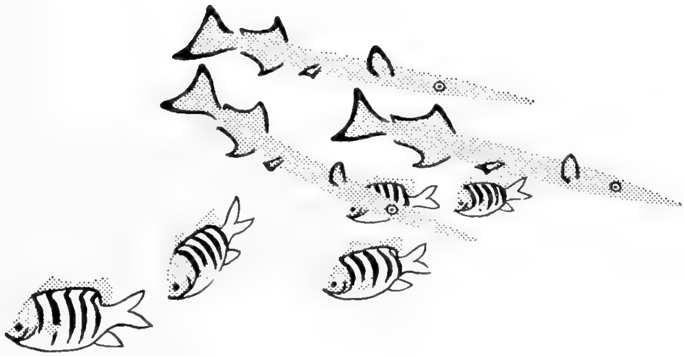
war time, and is transmitted by the body louse which is exhibited as an enlarged model in Case 7. The carrier of Plague or Black Death, a flea, is also presented as a model in this same group. Everyone has come into contact at one time or another with the common house-fly. This insect, although primarily a food contaminator, is also a carrier of filth diseases and typhoid fever. Enlarged models in Case 7 show the eggs, larva, pupa and adult. Most of the models shown in Cases 6 and 7 are enlarged 74 diameters or 400,000 times the volume of the actual specimens.

Case 8 contains actual specimens and enlarged colored paintings of the tick which carries Rocky Mountain spotted fever, a bug that carries Chagas disease, and the flies that are responsible for African sleeping sickness, Tularaemia and Filariasis.

On the first floor Roosevelt entrance, in the section dealing with New York State exhibits, the visitor will find on the south wall in the corridor some examples of the butterflies and moths of New York State. These are actual specimens and beneath each is the correct name. Several of the species also have their immature stages illustrated in color. The viewer should remember that this is not a complete collection of the butterflies and moths of New York State although most of the common species are represented.

It is hoped that those individuals who have occasion to visit the insect and spider exhibits will find them stimulating and that they will be encouraged to make their own observations. Insects and spiders are so abundant in nature that it is not difficult for the average individual to find many interesting problems within his immediate surroundings. Many important observations on insect behavior and biology have yet to be made and important discoveries can be forthcoming from the careful amateur observer. We hope the insect hall serves as an introduction to many of the interesting phases of insect and spider life.

FISHES



From earliest times, man has taken much of his food from the waters of the earth. The oceans, seas, lakes, ponds, rivers and streams abound in fishes and man has discovered many ingenious ways to catch them by hook, arrow, spear, net, trap and drug.

Today, we are still fishermen in the world's waters. Much of our food is taken from both salt and fresh water. We depend on fish for many raw materials as well. Much oil, fertilizer, medicine and leather are obtained from fishing. Millions of people fish for a living and millions more fish for sport and relaxation.

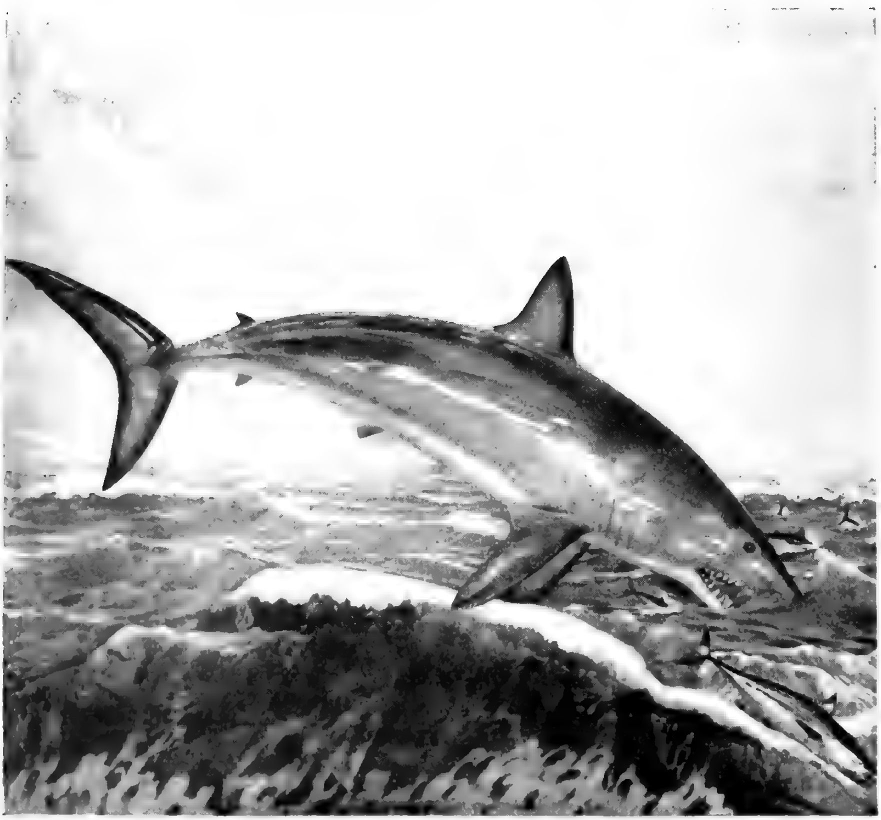
The scientist looks at fishes from a different viewpoint. He studies their physical structure, classifies them as to species, and finds out as much as he can about their distribution, migrations, feeding, choice of bottom, abundance, size and growth. Such information is of great value to other scientists, and at the same time is sought by educators, fishermen, industry and the general public.

THE EXHIBITS

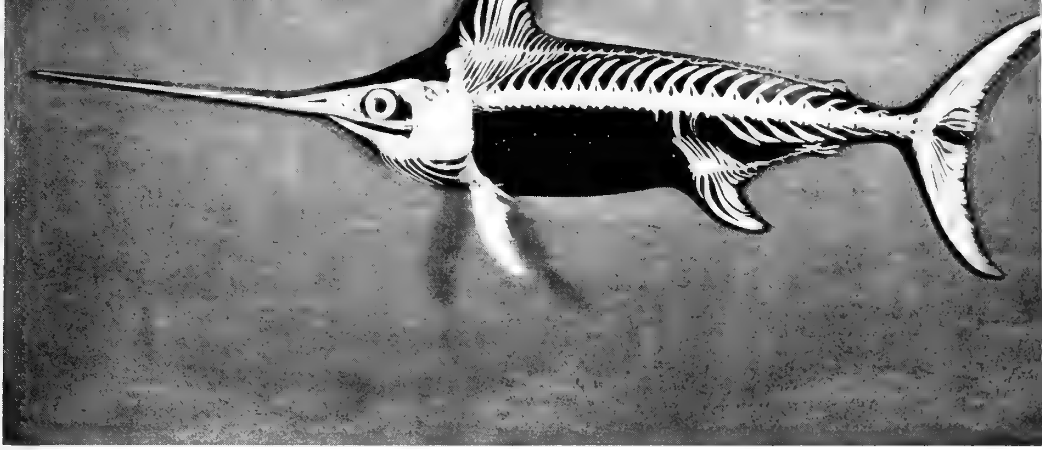
On entering the Hall of Fishes from the Hall of North American Forests, one faces a group of sharks sweeping down upon a helpless logger-head turtle. The following sharks are represented in this group:

(1) WHITE SHARK or MAN-EATER. One of the largest sharks, growing to a length of 30 feet or more. This ferocious shark feeds on large fish and sea-turtles. It has been known to attack men and even small boats. Fortunately, it is apparently rare everywhere.

THE SEA ROVERS. An undersea scene showing a number of sharks attacking a sea turtle.



MAKO SHARK GROUP.



SKELETON OF A SWORDFISH.

(2) SPOT-FIN GROUND SHARK OR SHOVELNOSE. May be recognized by its small second dorsal fin and very long tapering pectorals, in combination with a flattened, shovel-like nose. It produces living young, feeds chiefly on fishes and squid, and is harmless to man.

(3) SOUTHERN GROUND SHARK. Somewhat resembles the Tiger Shark but differs in its very blunt snout, stouter body, very large pectoral fins and complete absence of spots. It lives in coastal waters and feeds on fishes. It is common about wharves, where it picks up refuse. It is not dangerous to man.

(4) TIGER SHARK. This fish sometimes reaches a length of 30 feet and is a very active predatory shark. It has wide jaws and powerful sickle-shaped teeth. It preys on large sea-turtles, other sharks, fishes and invertebrates. The Tiger Shark is much dreaded in the West Indies, but there are no authentic records of attacks on humans.

(5) HAMMER-HEAD SHARK. This shark is characterized by a grotesque elongation of its eye stalks. It occasionally reaches a length of 12 feet.

(6) SAND SHARK. This shark lives chiefly on small fishes which it captures in great numbers.

THE SYSTEMATIC EXHIBIT includes a representative series of fishes, from the lowly "cartilege fishes," such as the sharks and rays, to the highest or most complexly constructed bony fishes. Noteworthy in this series are the mounted groups of "ganoids," including the sturgeons, spoonbills, bony gars and bowfins. In the alcoves and wall cases to the right, the visitor finds many curious forms, such as the giant catfishes, the handsome rooster fish, the brilliant parrot fish and butterfly fishes.

On the left side of the SEA ROVERS group is the BIOLOGICAL EXHIBIT. This considers the fish as a machine – its streamlined form, its main principles of construction, its machinery for motion, and the mechanism of its jaws.

BIG GAME FISHES. At the end of the Fish Hall, toward the Roosevelt Memorial, is the exhibit of Big Game Fishes, including many of great size taken with rod and line, chiefly by Michael Lerner and Zane Grey. The huge ocean sunfish, taken by Mr. Grey, weighed nearly a ton.

The central feature of the SAILFISH GROUP is the mounted skin of a fish caught off the rocky coast of Cape San Lucas, Lower California. It is shown in the act of leaping from the water in a desperate effort to shake the hook from its jaws.

Many other fishes well known to anglers and sportsmen hang in these cases, such as salmon, trout, perch, muskellunge, barracuda, yellowjack, bonefish, and the like.

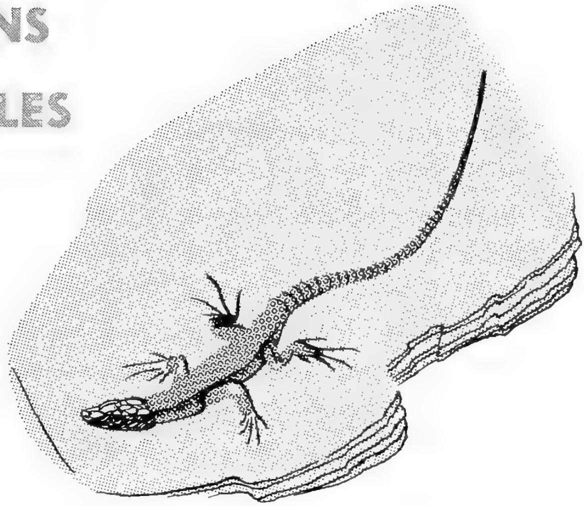
Three fine specimens of the fishes caught and presented by Michael Lerner are exhibited in special cases as if rising through the water. One is the mounted skin of a tuna *(Thunnus thynnus)* which measured 8 feet, 3 inches in length and weighed 557 pounds. It was caught on rod and reel off Wedgeport, Nova Scotia. This is the common or BLUEFIN TUNA, also called Tunny and Horse Mackerel. It occurs in both the Atlantic and the Pacific, and huge specimens may reach a weight of over 1,000 pounds.

The second specimen, a BLUE MARLIN *(Makaira nigricans ampla)*, weighed 305 pounds and measured 10 feet in length. It was caught on rod and reel off Bimini, Bahamas. A MAKO SHARK *(Isurus oxyrhynchus)*, also caught off Bimini, is shown lunging above the surface of the water to catch an escaping albacore.

The tuna, the swordfish, the marlin, the sailfish and the mackerel are all related, belonging to the same suborder of fishes, the Scombroidei, a group which reaches the acme of streamlined form and speed.

On the right of the exit from the Fish Hall is a large exhibit, THE LIFE HISTORY OF THE SWORDFISH, tracing the development of the swordfish from a tiny egg to the adult.

AMPHIBIANS AND REPTILES



The branch of biology that deals with the amphibians and reptiles is known as *herpetology*. In its broadest sense herpetology is concerned with the origin, evolution, distribution and classification of the amphibians and reptiles, their relationships to their environment, their life histories, their habits and behavior, and their structures and their functions. Herpetology is also concerned with the economic importance of amphibians and reptiles, and their bearing on the activities of man. The study of extinct amphibians and reptiles is more often included under paleontology.

Amphibians are backboned animals with a moist glandular skin. If scales are present they are usually hidden in the skin, and amphibians lack the protective covering of feathers or hair seen in higher vertebrates. The eggs of amphibians are usually laid in water or at least in moist places, and most of them pass through a fish-like, water-dwelling stage before metamorphosing or changing to the adult form. There are three major groups of living *Amphibia:* (1) the caecilians *(Apoda)*, superficially worm-like, limbless creatures, include burrowing as well as water-dwelling forms living in the tropics; (2) the salamanders *(Urodela)* or tailed amphibians, usually with four limbs, are largely confined to the northern hemisphere; (3) the frogs *(Anura)*, many of them popularly called "toads," are the tailless amphibians, otherwise characterized by their relatively long hind limbs and their hopping or leaping mode of progression. The three groups of Amphibia comprise a total of approximately 2500 living species.

Amphibians were derived from lobe-finned fish ancestors well over three hundred million years ago. Some fifty million years later one amphibian stock gave rise to the reptiles. Thus the amphibians are classed above the fishes, but below the reptiles.

Reptiles are backboned animals with dry, scale-covered skins. Some reptiles give birth to their young, but most of them lay eggs, always on land. Upon emergence from the egg, the reptile is similar to its parents and equipped to obtain oxygen from the air. The major groups of reptiles include: (1) the turtles *(Testudinata);* (2) the alligators and crocodiles *(Crocodilia);* (3) the "beak-heads" *(Rhynchocephalia)* represented by a single species, the relict Tuatara, *Sphaenodon punctatum,* of New Zealand; and (4) the lizards and snakes *(Squamata),* respectively included as subgroups of a single order owing to the existence of snake-like characters in several lizards and the retention of limb-girdles in some snakes.

Approximately 7000 kinds (species) of reptiles are still in existence, and many more passed into oblivion or are known only from their fossilized remains. The reptiles flourished at an early period of their evolution, which began well over two hundred million years ago. The original stock gave rise to such gigantic forms as some of the dinosaurs. Other stocks led independently to the warm-blooded mammals and birds. But several other stocks, including the larger "ruling reptiles," failed to survive. The modern reptiles include few species of great size; some marine turtles may reach a ton in weight and crocodiles 24 feet in length may weigh even more. The largest surviving lizard is scarcely ten feet long, but some snakes are believed to exceed thirty feet.

Unlike the birds and mammals, which produce heat internally, the amphibians and reptiles depend largely upon sources of heat outside the body. Some birds migrate to warmer climates in winter but others can remain abroad throughout the year, even in colder climates. Similarly, some mammals are continuously active, although others are forced to retire underground to avoid extremes of heat or cold. In this respect they are not unlike the reptiles, from which they differ in being heated internally while they are active.

One of the major research projects of the Department of Amphibians and Reptiles is concerned with the regulation of the body temperature in amphibians and reptiles. Investigations have disclosed the fact that many reptiles can maintain relatively high as well as fairly constant temperatures while they are abroad and active. They bask or seek out warm ground to raise the body temperature. When they become too hot they retire to shade or to shelter underground where their heat can be dissipated. Despite the fact that reptiles depend upon heat derived directly from the sun or from their surroundings, many species maintain body temperatures higher than those of man and other mammals. Thus, while reptiles are commonly termed "cold-blooded," it has become apparent that, when active, many reptiles are quite as warm as their more advanced relatives, the birds and mammals.

It is of fundamental importance, however, that the internal heating mechanism of birds and most mammals provides them with greater freedom in their activities than the amphibians and the reptiles possess. Nevertheless, it seems manifest that many elements of the highly complicated mechanism of heat production in the mammals had their origin

in the reptiles. The same portion of the brain that is sensitive to temperature changes in mammals is also heat sensitive in reptiles. Thus, by studying the origin and evolution of the mechanism of heat regulation in reptiles and the more primitive mammals, it is possible to improve our understanding of heat regulation in man, a matter of medical importance.

The Department of Amphibians and Reptiles has also carried out research projects concerned with the venom and the venom apparatus of cobras, their distributions and relationships, matters of particular importance in dealing with problems of snake bite and the therapeutic uses of venom. Similarly the Department has conducted a thorough investigation of the one family comprised of venomous lizards, the Gila monster of the United States and its Mexican allies.

Other studies by the scientific staff include those made of snake locomotion, of methods of eradicating venomous snakes, of the sense organs employed by snakes in their recognition of enemies, of tooth and fang replacement in reptiles, of homing behavior in toads, and of moisture loss in relation to habitat selection in reptiles. Many investigations have dealt with the classification of individual groups of reptiles and amphibians, or with the faunas of individual areas. Few of these projects yield results of direct economic significance. Many of them are much more concerned with the elucidation of evolutionary or distributional principles. It is of value to learn how and where amphibians or reptiles live, how they reproduce, or how they are affected by their environment, but not only because this information is intrinsically interesting. Largely it is a matter of extending the scope of human knowledge and in part it is a matter of satisfying man's curiosity concerning the unknown. For a thorough understanding of our world depends upon the assemblage and interpretation of precise information concerning all living things that surround us, and that constitute our environment in its broadest sense. And only by disregarding immediate utility in our assemblage of information is the widest utility to be served in the end.

THE EXHIBITS

The exhibits in the Hall of Living Reptiles depict representatives of all the important groups of amphibians and reptiles now surviving. As a means of furthering the scientific study of amphibians and reptiles, the Museum maintains one of the largest collections in existence. It comprises approximately 150,000 specimens and a large percentage of the species. However, scarcely 700 specimens have been used in exhibits, which display nearly 400 species, or only one out of each twenty-four that are known to science. For the individual specimens on display have been carefully selected to illustrate some peculiarity, to show some interesting attribute of the species or to illustrate a biological principle.

Upon coming into the hall from the Insect Hall to the south, the exhibits one first sees are the floor cases. These display many of the larger reptiles, the relatively gigantic crocodilians, the large land-

dwelling tortoises, and fresh water turtles, and the venomous snakes of maximum-sized species, including the king cobra, longest of all venomous snakes, the two largest kinds of the rattlesnakes, and the larger of the two species of venomous lizards. Interspersed with these are smaller habitat groups showing one of the large monitor lizards, an inhabitant of the regions occupied by the Asiatic cobra and Russell's viper. Other floor groups depict the timber rattlesnake and the copperhead, the two snakes most often responsible for injuries from snake bite in the eastern portion of the United States.

At the right of the entrance leading from the Insect Hall is the splendid group depicting the "dragon lizards of Komodo," the largest of living lizards, with a maximum length approaching ten feet. These great lizards, with a range confined to the East Indian Islands of Komodo, Padar, Rintja and Flores, are members of the monitor family *(Varanidae)*. This group of lizards is no longer represented in North America where it existed in prehistoric times, but it is now widely distributed in Africa, Asia and the Australian region. The exhibit shows the giant monitor in its native habitat on Komodo Island, where these lizards were collected and studied by the William Douglas Burden Expedition. The lizards were attracted by the carcasses of wild hogs, and the scene depicts a gigantic male ripping the meat from the dead animal as another lizard swallows a great chunk of meat already torn loose. A third lizard

DRAGON LIZARDS OF KOMODO. ***(Varanus komodoensis).*** **A male dragon lizard emerges from the dense jungle in search of food, using his long forked tongue like that of a snake to detect odoriferous particles in the air. This he does by inserting the tips of the tongue into a "pocket" of nerve endings in the roof of the mouth. A second smaller specimen crouches in a den that it has dug under the roots of a tree. This species, the largest lizard, is still in existence on the islands of Komodo, Padar, Rintja and Flores in the East Indies.**

MADAGASCAR CHAMAELEON. Among lizards, only the chamaeleon projects its extremley long tongue with great rapidity and accuracy to ensnare its insect prey at a distance that may exceed the length of its body. As in the frogs, the end of the tongue is sticky so that the insect is drawn back into the mouth with the tongue.

emerges from the dense undergrowth, its huge tongue thrust out as it picks up odorous particles that are carried to organs of smell in the palate, thus helping the reptile to find its food.

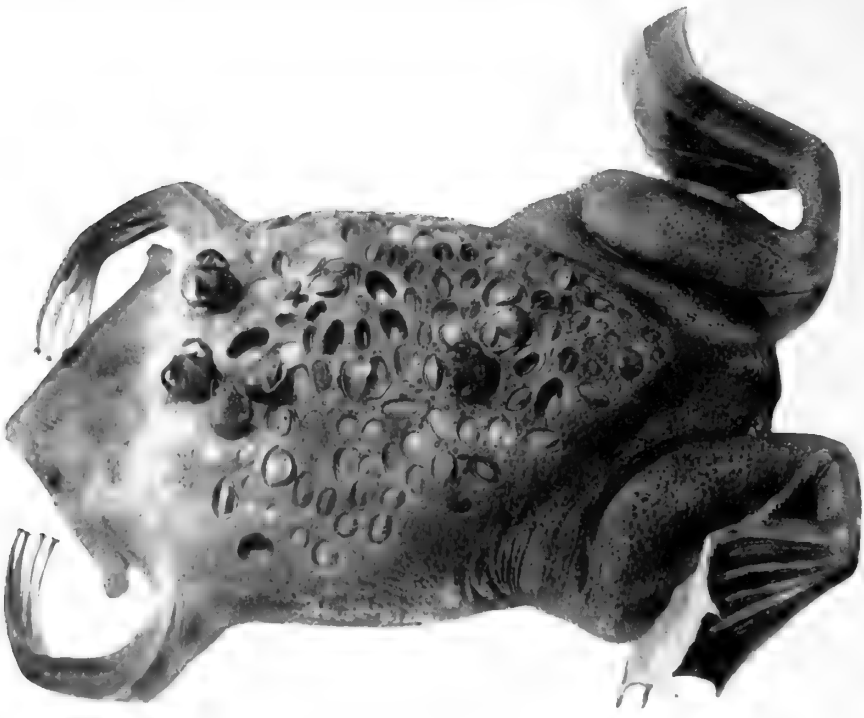
These huge lizards inhabit a region where there were no large carnivorous cats, wolves or similar mammals until dogs were introduced by man. Free from competition with such animals, the giant lizards became predators on the small deer, wild pigs and birds of the region, assuming the role ordinarily filled by the meat-eating mammals. The failure of the larger carnivorous mammals to reach Komodo and the adjacent islands therefore accounts for the survival of the largest lizard in these tiny islands where it remained undiscovered until 1912.

There is a vast amount of popular misinformation concerning snakes that is essentially folklore. Many erroneous notions are widely believed by otherwise well-informed people. Snake yarns, many of them dating back at least to Aristotle, are commonly accepted even though they endow the snake with capacities bordering on the supernatural. Thus an exhibit that contrasts the snakes of folklore with snakes as they actually exist seeks to correct these mistaken beliefs. This exhibit, labelled "SNAKES OF FABLE AND FACT," lies to the left of the entrance. Beyond this, along the left wall, the first of a series of exhibits in sunken panels illustrates the basic differences between amphibians and reptiles. what these animals are and why there are reasons for the belief that snakes were derived from ancestral lizard stock.

Continuing along the wall, this series of exhibits illustrates such biological principles as ADAPTATION, NATURAL SELECTION, ADAPTIVE RADIATION, ISOLATION and its evolutionary significance in the development of differences in form or habitat preference, the phenomena of PARALLEL EVOLUTION, and the selective importance of PARENTAL CARE, and of ATTRACTING or FRIGHTENING DEVICES. Another exhibit along the same wall explains the nature of the venom apparatus and the methods used in treating snake bite.

The corridor enclosed by the wall containing the sunken panels provides access to a series of habitat groups. These portray American reptiles and amphibians engaged in their normal activities under natural conditions. The subjects in their order from the front of the corridor are: the LEATHERBACK TURTLE; the GIANT SALAMANDER or Hellbender; the BULLFROG; a NEW ENGLAND MARSHLAND IN SPRING; WEST INDIAN TREE FROGS; REPTILES OF THE SOUTHWEST; the GALÁPAGOS IGUANA; the RHINOCEROS

SURINAM TOAD. The female Surinam Toad *(Pipa pipa)* of northern South America carries her eggs in shallow pockets on the back until they hatch as fully formed froglets. After being fertilized internally, the female deposits eggs by extruding the cloaca over her back. The male, perched on her back, presses the eggs into the female's back; each egg separately sinks into a pocket that forms to receive it.



RHINOCEROS IGUANA. The Rhinoceros Iguana *(Cyclura cornuta)*, the most powerful lizard in the Americas, inhabits the deserts of the West Indian Island of Hispaniola. The males shown here are fighting over territory that one of them is defending against the other as he will against all intruding males of the same species. The male on the left is undergoing his periodical shedding as evidenced by the patch of skin that is coming off his body.

IGUANA; and the GILA MONSTER. At the end of the corridor lies the FLORIDA CYPRESS SWAMP group.

Each of these groups emphasizes some noteworthy amphibian or reptile and its activities. The leatherback is the largest turtle in existence, with a maximum weight approaching a ton, and a wide distribution in the oceans of the world. The giant salamander, more or less strictly a stream dweller, is not the longest but probably the bulkiest amphibian in North America. It is one of the more primitive tailed amphibians, fish-like in some features of its reproduction. It is shown with its enormous eggs, laid in long bead-like strings. From his vent the male emits a cloudy substance containing the male germ cells, which fertilizes the large eggs that he remains on hand to guard.

In contrast, the bullfrog in the adjacent habitat group lays its eggs in clumps on the surface of pools. It is not so securely tied to the water,

for it preys upon a great variety of smaller animals on land as well as in the pools. The breeding activities of frogs are exemplified in the New England marshland exhibit, which shows male frogs and toads calling to attract mates whose eggs will be laid and fertilized in the adjacent water. Next in order is the diorama showing the activities of tree frogs, and the small lizards called geckos as they would be observed by a naturalist abroad with his flashlight during the night on a West Indian island.

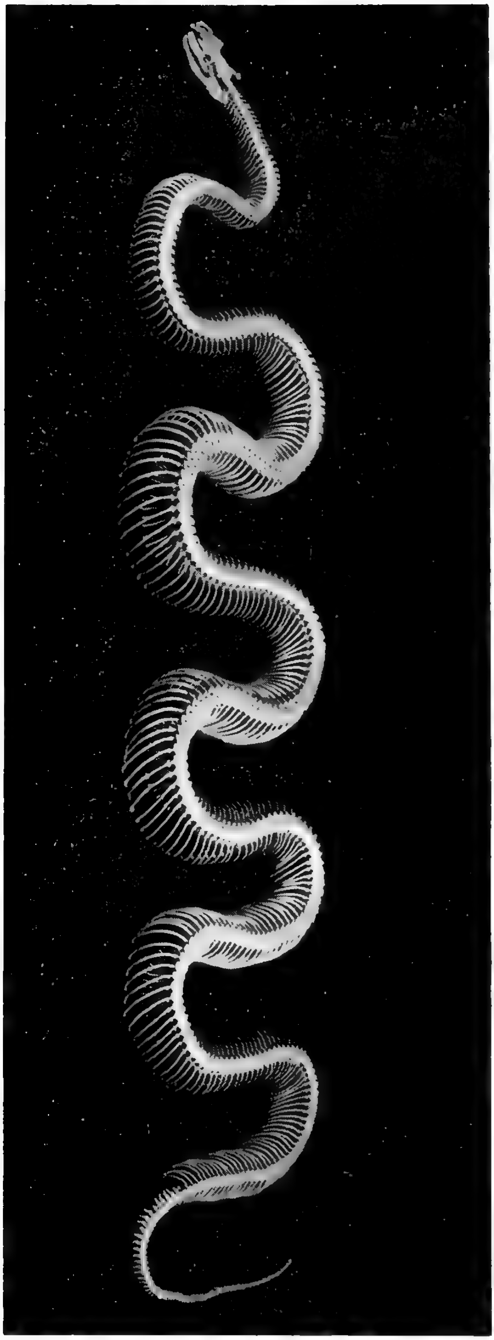
Reptiles, particularly the iguanas and their relatives in the New World, thrive in arid regions. The deserts of the southwestern portions of the United States extend into the peninsula of Baja California where such bizarre reptiles as the horned lizards share their habitat with the much larger herbivorous chuckawallas. Relatives of these desert dwellers have also reached many of the islands off the coast of the Americas. In the Galápagos Islands, off the coast of Ecuador, there are two large iguanas. One is confined to the land, but the other, the marine iguana more abundantly represented in the next group, lives on the rocky shores of these volcanic islands. Unlike any other lizard, it swims offshore to feed on marine plants.

Quite unlike this marine iguana, the rhinoceros iguana of the West Indian island of Santo Domingo inhabits the extremely arid portions of the island. The group illustrates the life history of the lizard, which is sufficiently powerful to dig its own burrows in the hard fossiliferous limestone. The eggs, buried in the sand, are deposited in July. When they hatch, the young iguanas push their way to the surface, sometimes carrying portions of the egg shell with them.

Near the end of the corridor is the Gila monster group, showing the only venomous lizard in the United States in its desert surroundings. The desert tortoise and the Sonoran whipsnake, other reptiles inhabiting the same region, are not molested by the Gila monster although their eggs, as well as those of lizards, are dug from the earth and eaten. The Gila monster also devours the eggs of birds and their nestlings, and not infrequently preys on juvenile ground squirrels, and sometimes eats smaller lizards.

Exhibits outside the corridor at the end of the hall illustrate how species arise as the result of isolation on mountain tops. To the right of the exit are two groups illustrating various ways that reptiles deposit their eggs. A diagram in between explains the significant advances in reproduction represented by the reptile egg, which contains a large amount of yolk and is similar in many respects to that of the birds and the egg-laying mammals. The reptile egg allows the developing embryo to obtain its oxygen directly from the air. Moreover, it contains other structures that eliminate the need for water so that reptiles are not so restricted in their habitats as their amphibian ancestors must have been.

On the outer side of the hall there are series of reptile skeletons exemplifying the various modifications in bony structure, venomous



SKELETON OF A PYTHON. This reticulated python *(python reticulatus)* measured twenty-two feet and nine inches. The skeleton is made up of numerous vertebrae to which a pair of ribs is attached on each side. Snakes do not "walk on their ribs"; it is the muscles attached to these ribs, not the ribs, that enable the snake to move.

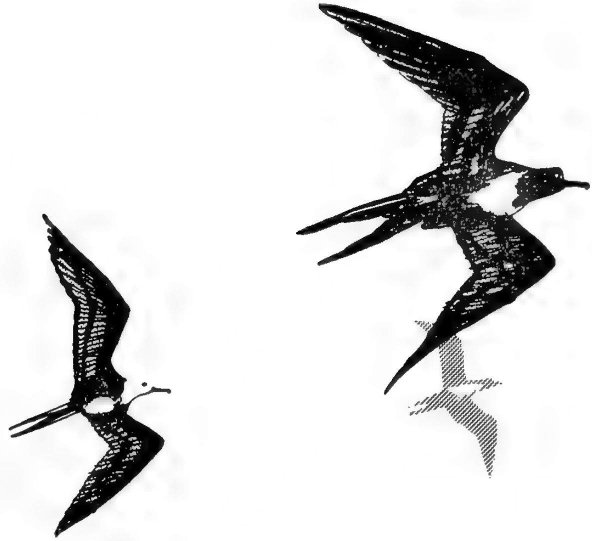
snakes noteworthy because of their potential danger to man, and typical representatives of several main groups of amphibians and reptiles. Many of the cases on this side of the hall answer such questions as "How do reptiles and amphibians feed?" or "How do they breed?" and "What is the economic value of reptiles and amphibians?"

The Department of Amphibians and Reptiles is, at one and the same time, a storehouse, a schoolroom, a bureau of information, a research center and a source of educational and artistic exhibits. It encompasses the activities of a secondary school as well as those of a university, for it is not only searching out new facts and reaching new conclusions from them but also presenting this information in such a manner that it can be grasped by the elementary student or by the interested layman.

Amphibians and Reptiles of the New York Region

An exhibit showing the species found within a radius of fifty miles of New York City may be seen in the corridor of the Roosevelt Memorial Wing on the first floor. It is intended especially for the use of those who want to identify amphibians or reptiles encountered in their back yards. It is of general interest in showing the number of kinds of salamanders, frogs, turtles, lizards and snakes encountered within a limited region surrounding the metropolitan area.

BIRDS



The science of bird study in all its aspects is known as ornithology. Like other branches of zoology, the study of animal life, ornithology began mainly as an attempt to determine the relationships, and to present a reasonable system of classification, of all birds, both living and extinct. In other words, the first challenge to an ornithologist was to describe and name the birds of the world and to divide them into species, genera, families, and higher categories of kinship. This end has now been attained, perhaps to a greater extent than in any other class of animals. Somewhat more than 27,000 forms of birds (species and subspecies) are known.

The curve of new discoveries has long passed its steep rise and has flattened out, owing to the fact that on an average only about two new species of birds are now found annually in all the world. Possibly fewer than 100 yet unknown species remain to be discovered. The situation contrasts strongly with that in the very much larger class of insects in which it is virtually certain that hundreds of thousands of species are yet to be found and described.

The foregoing statement does not mean that the day of systematic study in ornithology is past. There is still plenty to learn about the relationships of the higher groups (families and orders), besides which new methods in systematics, as applied to populations of closely related birds, are constantly leading to a better understanding of the processes of evolution.

It is true, neverthless, that about the beginning of the present century, when research in experimental zoology was coming to the fore, the contemporary interest in birds began to fall into a certain disrepute as a scientific subject. Professional careers for ornithologists were at that time limited in the United States chiefly to museums and to a few federal or state departments.

Now, happily, all of that is changed for the better, and we may confidently report that ornithology leads in several branches of biological investigation, such as those relating to speciation and the steps of evolution, to animal psychology (behavior), to the study of population dynamics, geographical distribution and ecology.

Migration, homing and direction-finding, the whole field of the bird's innate abilities, its "mind" and its instinctive, as distinguished from its learned, responses, its genetics and adaptations are today being widely studied by critical experimental methods. A quantitative and statistical approach has taken the place of the former aim of random observation coupled with the amassing of collections of skins, eggs and nests.

It is the living bird that has come to offer the most fruitful opportunity for research and that ties up most closely with the study of other animals, including man. As a result of all this change and growth, many universities today seek trained ornithologists as regular members of their biological faculties, and the future of the discipline of ornithology has never seemed brighter or more comprehensive.

THE WHITNEY WING

The Whitney Wing of the Museum, newest section of our structure, was a joint gift of the late Harry Payne Whitney and the City of New York. It is wholly occupied by the Museum's Department of Birds. Three of its eight floors are devoted completely or in part to public exhibits.

The Whitney Memorial Hall of South Pacific Birds

The main entrance of this wing leads into Whitney Memorial Hall from the New York State Theodore Roosevelt Memorial. The display represents bird life on islands in the Pacific Ocean, covering an expanse from Bering Strait southward beyond New Zealand and from the Galápagos Archipelago and small islets off the coast of Peru westward to the Australian barrier reef and New Guinea. Foyers at the ends of the hall contain maps and mural texts which describe both the purpose and plan of the exhibits. Here also are bronze busts of the late Messrs. William C. Whitney and Harry Payne Whitney, father and son, to whom the building and its contents are dedicated.

The design of this hall is intended to give the visitor the illusion that he is standing in the middle of the Pacific Ocean and viewing scenes in every direction throughout hundreds or even thousands of miles. In short, the hall represents the Pacific itself, reduced to extremely small compass. A common horizon crosses the background of all eighteen habitat groups and from these the sky appears to rise behind the fronts of the cases and to be continuous with the blue dome that forms the ceiling of the hall. Suspended by invisible wires in this vault are examples of oceanic birds which inhabit the Pacific from the tropical environment depicted near the northern end of the hall to the edge of the Antarctic toward the south end. It is through the latter that the visitor approaches from the Roosevelt Memorial building.

The eighteen habitat groups, beginning at the right of the entrance, are as follows:

SHIP-FOLLOWERS. The point of view is from the deck of an old-fashioned sailing vessel in the open sea south and east of New Zealand, in the zone of the westerly winds. In the background is the Whitney South Sea Expedition schooner, the "France," which served the American Museum during ten years in Polynesia. The expedition collected many of the specimens used throughout this hall.

Pelagic birds shown in the exhibit comprise a variety of albatrosses and petrels, especially characteristic of the higher southern latitudes.

SAMOA. A view from the hills of the island of Savaii toward the ocean. The site is at the point where forest meets more open slopes. The birds include those of both woodland and grassland, such as fruit pigeons, ducks, members of the parrot family and many smaller forms. Especially noteworthy is the Tooth-billed Pigeon *(Didunculus)*, a very peculiar member of the pigeon family, confined entirely to a few islands of the Samoan group.

TUAMOTU. The island of Hao, an atoll, with the coral-grown lagoon at the left and the surf of the open ocean on the right. In the distant background, tree-and-shrub-covered segments of the island ring can be seen. Among the coconut palms and other typical beach vegetation of a coral island are man-o'-war birds, boobies, a nesting Red-tailed Tropic-bird, several terns, including the white Fairy Tern which lays its egg on rough bark or in the crotch of a bush, and also a number of shore birds of both migratory and resident species. The example of the latter is the rare or nearly extinct Polynesian Sandpiper, one of the smallest members of its family, of which two stand in the left foreground.

The Tuamotu archipelago occupies a huge area in the central South Pacific and is one of the most extensive island groups on earth.

MARQUESAS. A scene in the volcanic island of Nukuhiva, showing a rugged shore line and ridges dissected by the sea, as viewed from a height of nearly 2,000 feet. On the right is the Valley of "Typee," famous as the locale of Herman Melville's romance of the same name.

The birds include the giant pigeon which exists only at the island of Nukuhiva, a smaller native fruit pigeon, swifts of the "edible-nest" group, warblers and Old World flycatchers peculiar to this island, a forest rail, a ground dove and a pair of wild chickens or jungle fowl, the ancestors of which were widely distributed in the Pacific by the original Polynesian immigrants.

PERUVIAN GUANO ISLANDS. Looking southward across the Bay of Pisco, Peru, from the southern island of the Chincha group. The scene shows the rainless coast of Peru where climatic conditions are responsible for the accumulation on such islands of sea bird manure, known as guano, which was the fertilizer of the Incas and other ancient farming peoples of the west coast of South America.

Despite the exhaustion of the old supplies of guano, it has again become an important commercial resource in Peru and the industry is now operated upon a scientific conservational basis.

The three principal species of guano-producing birds, all of which

PERUVIAN GUANO ISLAND GROUP IN THE WHITNEY HALL OF PACIFIC BIRDS. This exhibit shows several guano islands in the Bay of Pisco, Peru, with their bird life. The guano-producing birds represented are the Peruvian cormorant, pelican and booby. Also included are the Peruvian penguin, Inca terns and two species of gulls.

are peculiar to the coasts of Peru and northern Chile, are shown. These are the Peruvian Cormorant, the Peruvian Booby, and the Peruvian Pelican. Other birds of interest are the white-moustached Inca Tern, two species of gulls, and on the rocks of the painted background a distant cluster of Peruvian Penguins.

GALÁPAGOS. This scene is in the heart of the Galápagos archipelago looking from James Island across the water toward Albemarle, the largest island of the group. The Galápagos lie on the equator about 600 miles west of the South American coast. They are famous as the native home of many peculiar and long-isolated species of both plants and animals, and they received their first notable scientific fame as a result of the visit of Charles Darwin in H.M.S. "Beagle," in 1835.

Man-o'-war birds, herons, an owl, mockingbirds and hawks are among the birds shown in the exhibit. Most of these are remarkable because of their total lack of shyness in the presence of man, a trait doubtless acquired during residence throughout a very long period in a land without man or other mammalian enemies.

The most important of the Galápagos birds from a biological point of view are several species of small finches which show a great variation in the size of the bill. These mostly belong to the genus *Geospiza*, and Darwin's observations of them in the field are believed to have had much to do with his original ideas on the principal of natural selection as an explanation of evolutionary change.

HAWAII. This exhibit shows a deep and steep valley on the Hawaiian island of Kauai, with slopes and gorges going down about 4,000 feet from the high plateau of the island toward low banks above the beach. The

opposite or windward side of Kauai is extremely rainy and, on the right, fragments of storm clouds are shown whisking out over the valley, which, however, is not very humid because most of the rain falls farther to windward.

The Hawaiian archipelago, like that of the Galápagos, has been isolated from other land areas throughout many ages, and some of the native birds and other animals show even more peculiar and pronounced evolutionary changes. The Hawaiian honeycreepers *(Drepanididae)*, for example, are obviously members of a single family of small land birds, yet the specializations in the bills of several species range from short, stout, almost parrot-like beaks to extremely long, pointed and sickle-shaped organs. Feeding habits are, of course, correlated with such structures, for the stoutest-billed species can handle hard seeds and fruits, whereas those with long slender bills must use them in taking nectar or small insects and spiders from inside flowers. Several examples of these honeyeaters are shown, but it would be impossible to display the whole range of variation in bills without drawing upon species inhabiting other islands of the Hawaiian group.

At the right of the group three geese are shown in flight, the species being peculiar to Hawaii. In the air, down the valley, are two White-tailed Tropic-birds, and the small land birds include one or more species having tufts of brightly-colored feathers which were used by the ancient Hawaiians in making the famous feather cloaks worn by chiefs of high rank.

LAYSAN. Albatrosses, of which there are some seventeen species in the world, resort during the nesting season to remote oceanic islands. There they carry on their remarkably elaborate courtship procedure, lay the single egg, and rear their chick before they depart once more on the oceanic wanderings which continue until the return of the next breeding season.

Most albatrosses inhabit the higher latitudes of the southern oceans and no species regularly enters the North Atlantic. The North Pacific Ocean, however, is the home of three kinds of albatrosses, two of which are here shown on the nesting ground of Laysan Island, a leeward outlier of the Hawaiian archipelago.

The two species shown are the white-breasted Laysan Albatross and the all-dark, Black-footed Albatross. Both carry on an extraordinary ritual, commonly known as a courtship dance, although it really partakes of community behavior. The birds on the nesting ground salute, cross bills and bow not only to their own mates but to other albatrosses of both sexes.

A pair of the small native teal of Laysan, found nowhere else in the world, is also shown in this exhibit. Others displayed are nesting sea birds, such as boobies, man-o'-war birds and petrels (which occupy burrows in the sandy soil), and shore birds that make the island a resting place during their long migration from Alaskan breeding grounds to a winter home among islands of the south seas – Bristle-thighed Curlews, Golden Plovers, and others.

NEW CALEDONIA. This large island, which is east of Australia, lies on one of the western Pacific arcs or submerged mountain ranges. It has had no connection with any other land area since it rose from the ocean in the early part of the Age of Mammals.

Because its life has been obtained by natural means from places across the sea, it is interesting to note that, among the 64 species of New Caledonian land birds, 6 belong to widespread Pacific species, 35 appear to have come from Australia, and 23 from the New Guinea region.

New Caledonia has five genera of birds found nowhere else, these comprising a pigeon, a parrot, a warbler, a honey-eater, and the strange flightless heron-like Kagu. The last is a very extraordinary bird which seems to have no near relatives anywhere else in the world.

The site of this exhibit is on the northeasterly coast of New Caledonia, at an altitude of slightly more than 1,000 feet. The birds, in addition to the Kagu (on the ground), include a fruit dove, kingfisher, cuckoo, warblers, flycatchers, whistlers, a wood-swallow, starling, honeyeaters and a parrot finch.

SOLOMON ISLANDS. Since the United States armed forces made history at Guadalcanal Island, the savage Solomons no longer seem so far away as they formerly did. In this exhibit of bird life in a hot, humid and mountainous archipelago, the background shows Guadalcanal itself. The foreground represents a small islet off the southeastern end of Guadalcanal, with a cluster of native huts, and a garden in which coconut palms, bananas, papaya, cassava, breadfruit, taro and sweet potato are growing on the site of a recently-felled tropical jungle.

The Solomon Islands have a rich bird fauna, with 128 species of land birds alone. The 21 species shown in the exhibit can therefore be only a representative selection. They include the following: the Brahminy Kite, a bird of prey; the brush fowl, or megapode, which lays its eggs in mounds of rotting vegetation so that the heat of fermentation may hatch them; several species of doves, parrots, lories and cockatoos, including the King Parrot, of which the male is green and the female a vivid red; the Whiskered Tree Swift and various other colorful representatives of Old World families, such as rollers, cuckoo-shrikes, flycatchers, sunbirds and flower-peckers.

PHILIPPINES. This exhibit shows historic Bataan Peninsula on the island of Luzon, as viewed from nearly 3,000 feet above the sea at the summit of Mount Cayapo. In the middle of the background is Corregidor, famous island fortress, lying in the channel between Manila Bay and the China Sea. The scars of war have been rapidly overgrown by tropical vegetation and the forests and animal life of the region are relatively unspoiled.

The Philippines have about 325 species of native breeding birds. Of these, 47 are shown in the exhibit, a number not more than half those that might readily be seen at the site.

PAPUA. The great island of New Guinea is almost like a continent in the wealth of its plant and animal life. Lying in tropical latitudes,

its vast mountain ranges nevertheless rise to the level of snow, as shown in the other New Guinea exhibit in this hall, the second beyond this.

The landscape of the Papuan group shows the Laloki River gorge behind Port Moresby in the southern foothills of the Owen Stanley Mountains. Although the site is only 9° south of the equator, the heat is never oppressive here. Rainfall averages 90 inches annually in the oak, tree-fern and beech forests of the mountains, but only about one-third of that in the eucalyptus-dotted grasslands behind the Port. At the right is the spectacular Rouna waterfall, 1,000 feet above sea level. The area is an historic one because it was near here that Allied forces, in bitter jungle warfare, turned back the tide of the Japanese onslaught in the Second World War. The area is now a tranquil wilderness inhabited by such species as the birds of paradise, crowned pigeons, cassowaries, and bower birds shown in the group. More than 100 species of native birds were observed in the vicinity of the Rouna Falls. Thirty-nine of these are displayed in the exhibit.

ISLANDS IN BERING SEA. Little Diomede and Big Diomede are two islands in Bering Sea, 50 miles south of the Arctic Circle and about midway between Alaska and Siberia.

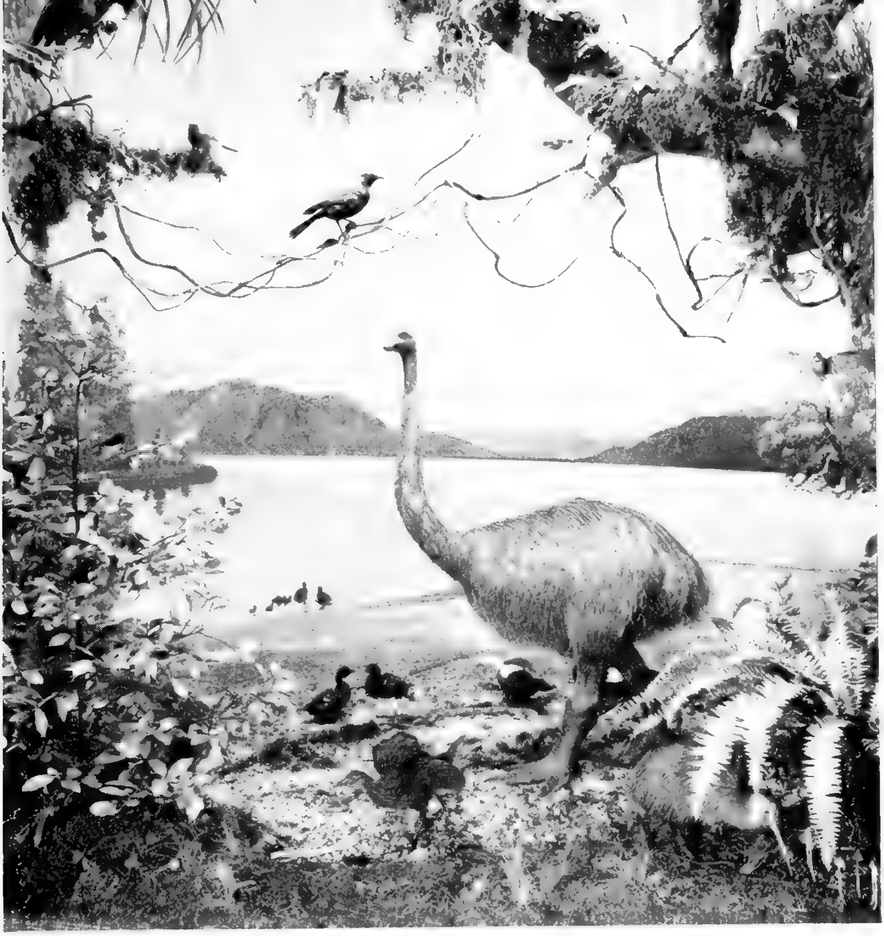
The site of this exhibit is the foot of a 1,000-foot cliff at the south end of Little Diomede Island. Here, protected by isolation as well as

ARCTIC SEA BIRD LIFE. From a group in the Whitney Hall of Pacific Birds. The group depicts the lower part of a 1000-foot cliff on Little Diomede Island in Bering Sea. Here myriads of sea birds come each summer to lay their eggs and rear their young.

THE GREAT BARRIER REEF, AUSTRALIA. Most of the flying birds in this view are sooty terns. The darker ones are part of a colony of brown noddies.

by the inaccessible nature of their haunts, myriads of murres, guillemots, puffins, auklets, gulls and cormorants come each summer to lay their eggs and rear their young.

SNOW MOUNTAINS OF NEW GUINEA. Among its 650 species New Guinea has many birds not known in Australia, though the two land masses are only 100 miles apart at Torres Strait. A drop of 50 feet in the sea level would probably join them. On a map of the United States, New Guinea would reach from New York City to Colorado, and its interior offers some of the largest unexplored areas on earth. This exhibit depicts a scene on Lake Habbema, 11,000 feet above sea level, looking southward toward Mount Wilhelmina. Parrots, birds of paradise and several kinds of flower-visiting birds, as honey eaters and flowerpeckers, are among the most characteristic birds of the area. Every altitudinal level has its own bird life, and few, if any, of these mountain species can be found in the tropical lowlands. Many of the Snow Mountain birds are very rare in collections, since they occur nowhere else in the world.



AN EXTINCT MOA OF NEW ZEALAND, reconstructed from a subfossil skeleton.

AUSTRALIAN BARRIER REEF. The Great Barrier Reef, which for more than 1,200 miles guards the east coast of Australia, is the largest coral reef in the world. In the extensive lagoon between the Barrier and the mainland are countless lesser reefs, islets of coral limestone and, near shore, higher islands which are detached fragments of the continental rock. Many of these have collected wind-blown soil and have acquired a luxuriant, even if limited, plant life. Others remain relatively bare, still far enough above the reach of the ocean to furnish breeding grounds for great colonies of sea fowl.

The birds of the Great Barrier are mostly of widespread types, as is characteristic of the avifaunas of beaches and small islands. They include a noisy colony of Brown Noodies and Sooty Terns, the fledgling young of the latter being the dark speckled birds which look so unlike their parents. Australian Silver Gulls, Crested Terns, Reef Herons in both gray and white phases, and man-o'-war birds complete the list of resident oceanic species. The sandpipers or tattlers in the beach pool are winter migrants from northern Asiatic nesting grounds. The white

land birds painted in flight are Nutmeg Pigeons bound, perhaps, toward fruit trees growing on the islets.

FIJI forms part of one of the several great island arcs to the east of Australia and New Guinea and comprises more than 200 separate islands and islets. The larger members are mountainous, and many are surrounded by fringing reefs of coral.

Fiji has about 54 species of land birds, or only half as many as the Solomon Islands which are hundreds of miles nearer the ultimate source of supply in the Australasian region. The principal Fijian types are birds of families known to be able to make long colonizing flights across the ocean, such as parrots, pigeons, kingfishers, starlings and white-eyes.

In the Silky Dove and the Golden Dove, Fiji has two of the most spectacular of all birds. Both species are peculiar to this group of islands, and one of them only to Viti Levu Island, the site of the exhibit. The thirteen additional birds shown all belong to families found at other Pacific islands, but the species are mostly peculiar to Fiji. Most of the aboriginal Fijian birds are confined to mountain districts, while the common birds of town and village are more widespread or recently introduced kinds.

NEW ZEALAND. The view looks across Lake Brunner in the South Island Alps. The period is that of several centuries ago when many species of the heavy and flightless moas lived as browsing and grazing birds in this isolated part of the temperate world. Both plants and birds shown belong to the older life of the islands, antedating the many kinds introduced by man that have since become very conspicuous in New Zealand. The landscape is on the western or rainy side of the mountains at the edge of tall forests of almost tropical luxuriance.

The flora and fauna of New Zealand are a product of marked isolation, the next large land area, Australia, being 1,200 miles away. Four-footed mammals appear never to have reached New Zealand until they were transported there by man. In the absence of enemies and of competing grazing mammals, the peculiar and highly specialized moas took the place of antelopes, wild cattle, etc. that lived in so many of the world's continental areas. *Euryapteryx*, a moderate-sized moa reconstructed from a subfossil skeleton, is centered in the exhibit. In the extreme left is a large flightless rail, the Takahe or *Notornis*, long thought to be extinct in New Zealand but recently rediscovered. Other birds shown include several native ducks, together with a pigeon, a falcon, an owl, three species of parrots and several kinds of honey-eaters and other song birds known only from New Zealand.

SNARES ISLAND. To the south of New Zealand, in the west wind zone, lies a small and rarely visited subantarctic group of islets which are called the Snares because they were regarded as a navigational hazard. Since they have never been inhabited by man or such of his domestic associates as rats, goats, pigs and weeds, the conditions today are much as they were in primitive times.

The climate is blustery, chilly and rainy, although never extremely cold. There are about 25 kinds of higher plants, including ferns, the most conspicuous elements being coarse, tall tussock grass and the "daisy tree" (*Olearia*) which forms an eerie forest. The large orange blossom-clusters belong to a groundsel shrub.

Seals of several kinds are the only mammals. The birds number a little over a score of species. They include Crested Penguins, albatrosses, petrels, gulls, terns and skuas. There are only two land birds, a tomtit peculiar to the Snares, and a fernbird. A nearly flightless grass snipe is, however, more of a land than a water bird.

In December, the southern "June," the sea fowl are nesting, and the multitudinous Sooty Shearwaters or "muttonbirds" fill the sky toward sunset before dropping each to its own soggy burrow.

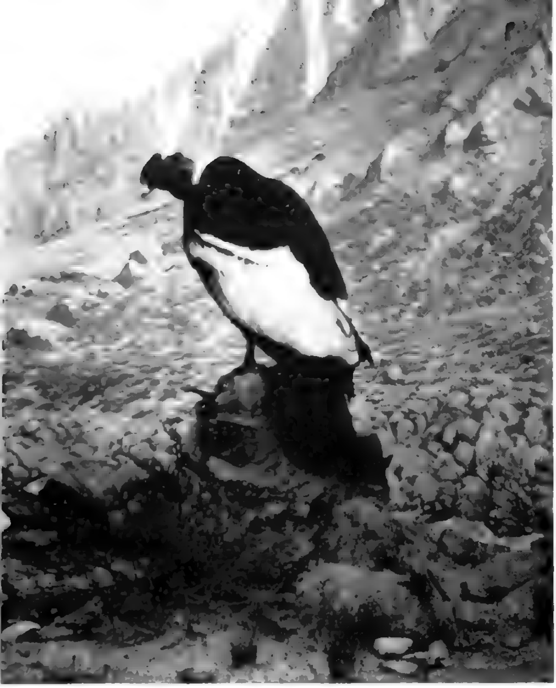
BIRDS OF PARADISE. The first case consists of two exhibits, one of the Plume-Birds of Paradise, and one of the South Sea Lories, a group of parrots. The second case contains an exhibit of the Rifle Birds (Birds of Paradise) and one of various birds of the Malay Archipelago.

Leonard C. Sanford Hall

The Sanford Memorial Hall of Biology of Birds is located in The Whitney Wing and is devoted mainly to diagrammatic exhibits illustrating the bird's place in nature and many aspects of the structure, descent, relationships and behavior of birds and their relation to man. The exhibits are in part technical, and they deal with fundamental scientific problems.

They are intended to be instructive rather than picturesque, although a large exhibit of tropical marsh birds in flight against a sunset sky faces the entrance of the Hall, and a number of other habitat exhibits show beautiful and spectacular birds, extinct species, and certain extraordinary aspects of reproductive behavior. At the left of the Hall is the synoptic collection of birds of the world designed to show in systematic sequence examples of virtually all of the families of birds and a large proportion of the more important genera.

EXHIBIT EXPLAINING THE PRINCIPLES OF FLIGHT.



Left, ANDEAN CONDOR. Detail of the high Andes Group. Right, MACAWS. Detail of Barro Colorado Island Group, Panama Canal Zone.

A number of remarkable fossil birds are exhibited in Sanford Hall. Among them is the toothed swimming bird, *Hesperornis,* which lived in the age of dinosaurs. There is also a skeleton of a giant moa, from New Zealand, and the skeleton of a giant, huge-billed bird, *Diatryma,* which lived in western North America some 50,000,000 or more years ago.

Elsewhere are considered the physiology, flight, feather covering, courtship, reproduction, geographical distribution, migration and other biological phenomena in exhibits of a chiefly diagrammatic nature.

BIRDS OF THE WORLD HALL

This hall is given over to a projected series of twelve habitat groups to show the major faunal areas of the world and their characteristic birds. Eleven groups have been completed. The backgrounds, by Francis Lee Jaques, Frank McKenzie and Arthur A. Jansson, are reproductions of actual scenes made from color sketches and photographs taken on the spot. Beginning at the right of the entrance, the groups are as follows:

PAMPAS GROUP. The pampas and lagoons of the South Temperate Zone of South America harbor a varied assemblage of birds. These include some twenty species of North American sandpipers and plovers that migrate to this region to spend the northern winter. Some of the birds are permanent residents. The scene is laid at Lake Chascomus, near Buenos Aires, Argentina, a region made famous by the writings of William Henry Hudson to whom the group is dedicated.

HIGH ANDES GROUP. The Paramo Zone of South America is found at sea level at the southern end of the continent but occupies increasingly high elevations in the Andes, below the snow line, as the equator is approached. In the neighborhood of Mt. Aconcagua, Chile, shown in the background, this zone is reached at 10,000 feet elevation, but the birds are still closely related to those of the lowlands of Patagonia and southern Chile. The Andean Condor is a characteristic species.

AMERICAN TROPICAL ZONE. Barro Colorado Island, in the Canal Zone, was once a hilltop and part of the unbroken humid tropical forest of the Panamanian lowlands, but it was cut off from the surrounding forest when the valley of the Chagres River was flooded by the closing of the Gatun Dam. It is now preserved as a natural laboratory under the care of the Institute for Research in Tropical America. It has been made known through the writings of Dr. Frank M. Chapman, particularly by his books "My Tropical Air Castle" and "Life in an Air Castle."

SOUTH GEORGIA GROUP. The bird-life of the Antarctic regions is not as rich in species as that of the tropics but possesses certain very interesting forms, among which the penguins are outstanding. The group shows an assemblage of King Penguins on the island of South Georgia, 1,200 miles east of Cape Horn. Among the other characteristic species are the Wilson's Petrel (one of the birds known to sailors as "Mother Carey's Chickens"), the Kelp Gull, Giant Fulmar, the curious Sheathbill, and (painted) the Wandering Albatross.

EAST AFRICAN PLAINS. The easterly third of Africa is largely a grassy country dotted with thorny bushes and trees. The Kidong Valley, scene of the group, lies some 40 miles northwest of Nairobi, Kenya Colony, in the Great Rift Valley that extends from northern Tanganyika to the Red Sea and southern Palestine. The Ostrich, Marabou, Bustard, Courser, Secretary Bird, Hoopoe, Coly and Lark shown in the group are typical of the plains region, though some of the other birds shown have close relatives in the forests.

CONGO FOREST GROUP. The equatorial forests along the Congo River in western Africa are rich in bird-life. As in other tropical forests, many species of birds often band together in loosely mixed flocks that roam the woods for insects and other food, searching from the ground to the tops of the trees. The exhibit shows such an assemblage of ant-chasers together with other inhabitants of the region. The scene is at Lukolela, about 500 miles upstream from the mouth of the Congo River.

AUSTRALIA. This is a scene in the Blue Mountains of New South Wales, about 100 miles west of Sydney, at the edge of the forest looking out over the eucalyptus-dotted savanna. Two Lyre Birds (male and female) have come to the forest margin. A flock of Crimson Rosella Parrots has settled on the ground and in the trees, and two Eastern Rosellas are nearby. Several Black-backed Magpies are on the ground or (painted) flying, and a Laughing Jackass is perched in a tree overhead. Various characteristic birds of eastern Australia are shown, such as the Peaceful Dove, Satin Flycatcher, Broad-billed Roller, Gang-gang

EASTERN ROSELLAS. Detail from the Australian bird group.

Cockatoo and others. In the distance (painted) are scattered the ostrich-like groups of emus.

GOBI GROUP. The extensive desert of central Asia, known as the Gobi, contains a number of brackish lakes, without outlets and fed by surface and underground streams from mountains such as the Altai Range shown in the background. The climate is cold except for a brief summer, and the bird-life consists largely of migrant species that go south for the winter, as the Demoiselle Crane, Great Bustard and Ruddy Sheldrake. The Raven remains throughout the year. The interesting Sand-Grouse often travels long distances daily for water and has an irregular local migration.

PALAEARCTIC ALPINE GROUP. The Zermatt Valley and the Matterhorn, in Switzerland, are shown with some of the birds of the upper Alps at timberline at 7,000 feet elevation. Some of the species, like the Wall Creeper and the Snowfinch, probably reached the Alps from the Himalayas in prehistoric times when these two now distant mountain ranges may have been continuous. Others, like the Arctic Ptarmigan and Redpoll, may have come from the north, driven by the advancing ice of the Glacial Period. Still others are inhabitants of the lower elevations that have extended their ranges upward to the timberline.

NEW FOREST GROUP. The Palaearctic Zone or Old World Northern Temperate Zone corresponds to the Nearctic or North Temperate Zone of North America. The families of birds found in the two regions are much the same and some of the species are identical although their

local names may differ. Occasionally the same name is applied to quite different species as in the case of the European and American robins. The group shows the famous "Roosevelt Walk" in the New Forest, in the Valley of the Itchen, in Hampshire, where Lord (then Sir Edward) Grey and Theodore Roosevelt watched the birds together in 1910.

TUNDRA GROUP. Churchill, Manitoba, on the western side of Hudson Bay, lies in what the Indian called the "land of little sticks." Here the Canadian forests to the southward are giving way to the treeless tundra that reaches northward to the Arctic Ocean. In summer the tundra is dotted with inumerable insect-filled ponds. Here to nest come myriads of migratory water birds — sandpipers, plovers, gulls, ducks and geese — that have wintered in warmer lands to the southward. A few land birds also nest on the tundra. One of these, the Arctic grouse or Ptarmigan, is able to endure the long Arctic winter and, unlike most of the tundra birds, does not migrate. A number of forest- or bush-dwelling birds reach the northern limit of their distribution near Churchill. Some of these may be seen in the group.

HALL OF NORTH AMERICAN BIRD GROUPS

The backgrounds of the Hall of North American Bird Groups are reproductions of specific localities, painted from sketches made by the artist who usually went with the naturalists when the field studies for the groups were made. Practically all sections of the country are shown; thus the series shows characteristic North American scenery as well as bird-life.

ORIZABA GROUP. The distribution of birds, in spite of their power of flight, is limited in great measure by climate. Thus in traveling from Panama north to Greenland there are zones of bird-life corresponding to the zones of temperature. This condition is illustrated on the mountain of Orizaba in Mexico where, in traveling from the tropical jungle at its base to its snow-clad peak, the naturalist finds zones of life comparable with those to be found in going north on the continent.

COBB'S ISLAND GROUP. Among our most beautiful and graceful shore-birds are the terns and gulls, which were once ceaselessly hunted and killed for their plumage. Thanks to protection, they have now greatly increased in numbers. The group represents a section of an island off the Virginia coast where the birds are now protected by law.

DUCK HAWK GROUP. The Duck Hawk may be found nesting on the Palisades of the Hudson River almost within the limits of New York City. It nests on the ledges of the high cliffs. This hawk is the Peregrine Falcon, much used for hunting in the Middle Ages. It often comes into the city for pigeons.

HACKENSACK MEADOW GROUP. In August and September the meadows and marshlands bordering the Hackensack River, New Jersey, formerly teemed with bird-life. In the group are swallows preparing to migrate southward, Bobolinks or "Rice Birds" in autumn plumage, Red-

winged Blackbirds, Rails, Wood Ducks, and Long-billed Marsh Wrens. Industry and settlement have driven many of the birds to quieter haunts.

WILD TURKEY GROUP. The Wild Turkey is a native of America and was once abundant in the wooded regions of the eastern part of the United States. It differs slightly in color from the Mexican bird, the ancestor of our common barnyard turkey that was introduced from Mexico into Europe in 1502 and was brought by the colonists to America. The scene is reproduced from studies near Slaty Forks, West Virginia.

FLORIDA GREAT BLUE HERON GROUP. The Great Blue Heron usually nests in trees. The bird flies with its neck curved back on its body, and because of this habit it can be easily distinguished from cranes. Locale is near St. Lucie, Florida.

WATER TURKEY OR "SNAKE-BIRD" GROUP. In the yellow pond-lily swamps near St. Lucie, Florida, grown with cypresses and cabbage palmettos, the shy Water Turkey builds its nest. It gets the name "turkey" from its turkey-like tail, and the title "snake-bird" from its habit of swimming with only the long slender neck and head above water.

SANDHILL CRANE GROUP. Unlike the Herons, the Sandhill Crane builds its nest of reeds in the water. It differs also in its manner of flight, always fully extending its neck when on the wing. The scene is the Kissimmee Prairies of Florida.

BROWN PELICAN GROUP. Pelican Island, on the Indian River of Florida, has been made a reservation by the United States government to protect these grotesque birds. The view shows a section of the island at the height of the nesting season.

AMERICAN EGRET GROUP. This beautiful bird was once almost wiped out through the use of its "aigrette plumes" for hats. It is now found again throughout much of its former range, owing to effective protection. The birds have these plumes only during the nesting season, at which time the death of the parent means the starvation of the young. This group represents a rookery in South Carolina.

TURKEY VULTURE GROUP. The Turkey Vulture or "Buzzard" is one of the best-known birds of the South, where it is a valuable scavenger. It is protected by law and by sentiment and has become both abundant and tame. The scene is on Plummer's Island, above Washington, in the Potomac River.

CALIFORNIA CONDOR GROUP. The California Condor is the largest and one of the rarest birds of North America. In the group the visitor stands in the interior of the condor's cave, looking down on the river of the Piru Cañon, California.

BRANDT'S CORMORANT GROUP. The foreground of the group shows a detail of the island that is painted in the background. The young birds are feeding and it may be noted that one fledgling is reaching down the mother's throat after the predigested food.

SAN JOAQUIN VALLEY GROUP. This area was once an arid place with a characteristic desert bird fauna. Since ranchers have irrigated the land, aquatic bird-life is plentiful. This group is a good illustration of the influence of man on the bird-life of a region.

FLAMINGO GROUP. There were estimated to be two thousand nests in this colony in the Bahama Islands. The Flamingos make their nests by scooping up mud with their bills and packing it down with bill and feet. The nests are raised to a height of twelve or fourteen inches, protecting the eggs and young from high water. Only one egg is laid, and the down-covered young is fed by the mother on predigested food.

BOOBY AND MAN-O'-WAR BIRD GROUP. Part of a coral islet in the Bahamas shows three thousand boobies nesting on the ground and four hundred Man-o'-War birds nesting in the sea grape bushes.

FLORIDA ROOKERY GROUP. This Florida Everglades group shows Roseate Spoonbills, Snowy Egrets, American Egrets, Little Blue Herons, Louisiana Herons, Ibises, Cormorants and Water Turkeys. Because of the isolation of this island it was one of the last places to be visited by the plume-hunter.

WHISTLING SWAN GROUP. A Whistling Swan on the nest is seen far across the arctic tundra, the summer home of this species. The nest is of moss, etc., and in it are two to five white eggs, four and a quarter inches long. Both male and female share the labor of nest-building, incubation, and caring for the young.

AMERICAN EGRET GROUP, in the Hall of North American Birds.

GOLDEN EAGLE GROUP. The Golden Eagle is one of the most widely distributed of birds. In North America it is common from the Rockies to the Pacific, and as far east as Maine. Its food consists of rabbits, squirrels, woodchucks and occasionally lambs.

KLAMATH LAKE GROUP. The bird-life here shows how normal nesting habits may be changed by birds being forced to live in a new place. White Pelicans that usually make a nest of pebbles, Caspian Terns that commonly build their nests on sand, and Cormorants that nest on rocks are all nesting together here on the islets of the lake.

ARCTIC-ALPINE BIRD-LIFE GROUP. The scene in this group is above the timberline on a crest of the Canadian Rockies, 8,000 feet above the sea. Although those mountains are in the temperate region, the altitude gives climatic conditions that would be found in the far North, and the bird-life is arctic in character. White-tailed Ptarmigans, Rosy Finches and Pipits are nesting here.

SAGE GROUSE GROUP. The male Sage Grouse is shown, strutting and wooing a mate in the sage brush of a western plateau near Medicine Bow, Wyoming.

PRAIRIE CHICKEN GROUP. The Prairie Chickens are the common grouse of the western grasslands. The group shows a typical scene during the mating season. The male birds go through most surprising antics in their efforts to attract the females. They blow up the orange-colored sacs on the sides of their necks, dancing and strutting about, and uttering a loud, resonant, booming note.

CANADA GOOSE GROUP. The Canada Goose is one of the first birds to migrate north in the spring. It nests among the lakes of Canada even before the ice is melted. The Scene is at Crane Lake, Saskatchewan, Canada.

GREBE GROUP. The Grebes are aquatic birds, building their nests in the water. During incubation the parent usually covers the eggs with grass and reeds when leaving the nest. Nesting at the same lake with the Grebes was the Redhead Duck.

LOON GROUP. The Loon is justly famed for its skill as a diver and can swim with great speed under water. Its "laugh" and other calls are familiar sounds on the northern New England lakes. Many Loons pass the winter at sea fifty miles or more from land.

BIRD ROCK GROUP. This rocky island thirty miles from shore in the Gulf of St. Lawrence gives protection to the sea birds that still nest in considerable numbers on its cliffs. Seven species are shown nesting in the group – the Razorbilled Auk, Leach's Petrel, Gannet, Puffin, Kittiwake Gull, Common Murre and Brunnich's Murre.

MAMMALS

A mammal is a warm-blooded backboned animal, clothed with fur or hair. The young are fed with milk by the mother. Mice, cats, dogs, horses, elephants, whales, monkeys and men are mammals. Birds, snakes, frogs, turtles and fishes all have backbones but they are not mammals. They have neither fur nor hair nor do they nurse their young with milk.

The Department of Mammals is devoted to their study — classification, physical structure, developments, including growth and size, distribution, adaptation to environment, abundance and many other avenues of research. Field and laboratory investigation results are presented in both scientific and popular publications.

The Department also is responsible for the splendid natural habitat groups to be seen in the various halls. Here the visitor will see representative mammals from all parts of the world, together with the kind of environment in which they live. There is a multiple purpose in such exhibition. The visitor sees the animal at home, he appreciates the relationship between the environment and the kind of creature that can live in it, and he is brought to realize the necessity of preserving such environments if the animals themselves are not to be driven out of existence. Thus, both the aims of education and of conservation are served.

THE HALL OF NORTH AMERICAN MAMMALS

The Hall of North American Mammals is approached from the Hall of New York State Mammal exhibits. It was opened to the public on April 8, 1942. A few of the groups are still under construction.

At the west end of the hall, opposite the entrance, is the ALASKA BROWN BEAR GROUP. These great carnivores are shown against the background of the Pinnacles, steep mountains of the Alaska Peninsula.

ALASKA BROWN BEAR, the world's largest carnivore. It goes into hibernation on the mountain slopes in the fall and emerges in April or May.

A salmon lies on the shore of a small creek. The Otter that caught the salmon is being frightened away by the approach of the bears.

On either side of the entrance to the hall are small-scale groups, showing the mammals of North America and their environments during the Ice Age. These animals are now extinct here, although their close relatives exist in other parts of the world. Some of our living mammals could have been found in company with extinct ones. The group to the right shows the mammals found in Alaska. The group on the left depicts those that occurred in southern California.

The GRANT CARIBOU in their home on the Alaska Peninsula appear in the first large group to the right of the entrance.

WHITE OR DALL SHEEP. These three rams show a group of bachelors during a period of the year when the sexes do not mingle.

Next is the WHITE SHEEP GROUP. Handsome rams are resting far above the timber line on a mountain in Alaska, with the golden glow of the "midnight sun" striking the white peak of Mount McKinley in the background.

The ROCKY MOUNTAIN SHEEP GROUP shows remarkable differences of color and structure from the White Sheep. The massive, closely spiralling horns of the Bighorn contrast with those of the White Sheep. In the foreground may be seen a Mantled Ground Squirrel, locally called "Big Chipmunk."

The ALASKA MOOSE GROUP, in the center aisle, displays two great bulls locked in a struggle for mastery over a cow, which appears

THE BIGHORN SHEEP inhabits the rugged mountains far above the tree line and descends only when forced down by deep snow. The scene portrayed for this group in the American Museum is in Jasper National Park, Alberta.

unconcerned over the outcome. A number of Moose painted in the background indicate their abundance on the Kenai Peninsula, where the scene is laid. A Canada Jay, or Whiskey Jack, perches in a bush to the right of the fighters, and a Spruce Grouse is in a tree to the left of the cow.

The GRIZZLY BEAR GROUP, with a male, a mother Bear and her two cubs, is around the corner to the right. They are on the edge of the Canyon of the Yellowstone River in the National Park. The Falls are in the distance, and an Osprey, or Fish Hawk, its nest placed on a rocky pinnacle, soars in the middle distance.

The JAGUAR GROUP is located in Sonora, Mexico. Two Jaguars, America's largest spotted cats, crouch on a rocky mountainside at sunset.

The MOUNTAIN LION GROUP has for its background the picturesque Grand Canyon of the Colorado River. One Mountain Lion lies completely relaxed on the rocky floor of a shallow cave, while the other keenly watches the movements of a deer far below.

Behind the ALASKA BROWN BEAR GROUP is a faunal map of North America and photographs of mammals in the wild.

The WAPITI GROUP is on the opposite side of the hall from the MOUNTAIN LION GROUP. A splendid bull Wapiti, or American Elk, a cow, a yearling bull and a calf of the year are shown in the northern Colorado Rockies.

The VIRGINIA DEER, or Whitetail, still occurs in numbers in the New York Metropolitan area, as this scene in Bear Mountain Park testi-

WAPITI. This animal is generally known in America as the Elk. It in some ways resembles the European Red Deer.

fies. A buck, a doe, and a young of the year stand amid the brilliantly colored foliage of the eastern fall.

The MULE DEER GROUP is portrayed with the Devil's Tower, northeastern Wyoming, in the background.

BISON AND PRONGHORN ANTELOPE on the North Platte River, Wyoming, occupy the large case opposite the MOOSE GROUP. Vast herds of Bison formerly spread from the Appalachians to the Rockies and from Mexico to the Canadian Northwest. The Pronghorn, which is not an antelope and has no close relatives, is the only hollow-horned ruminant that sheds the horns annually.

A Prairie Dog is poking its head out of a burrow, and Cowbirds are associated with the Bison.

The MUSK OX GROUP, around the corner, demonstrates that the Musk Ox is well equipped for life in the rigorous Arctic regions. In its long, dense coat of fur and hair, it is quite at home in the blizzards of northern Ellesmere Land.

The ROCKY MOUNTAIN GOAT GROUP exhibits a billy, a nanny and a kid on a mountain in southern Alaska, overlooking a beautiful fiord, the Endicott Arm.

The OSBORN CARIBOU GROUP is placed against a background of mountain grasslands in northern British Columbia. Though these Caribou often move down into the forest during winter storms, they do not migrate like the Arctic Caribou of the tundras of the far north. A covey of Ptarmigan may be seen in the background.

THE MUSK OX is now restricted to certain parts of Arctic America, though in the Ice Age it ranged over most of Europe, Asia, and what is now the United States.

Behind the two largest groups, the Moose and the Bison, are the north and south galleries, containing smaller habitat groups.

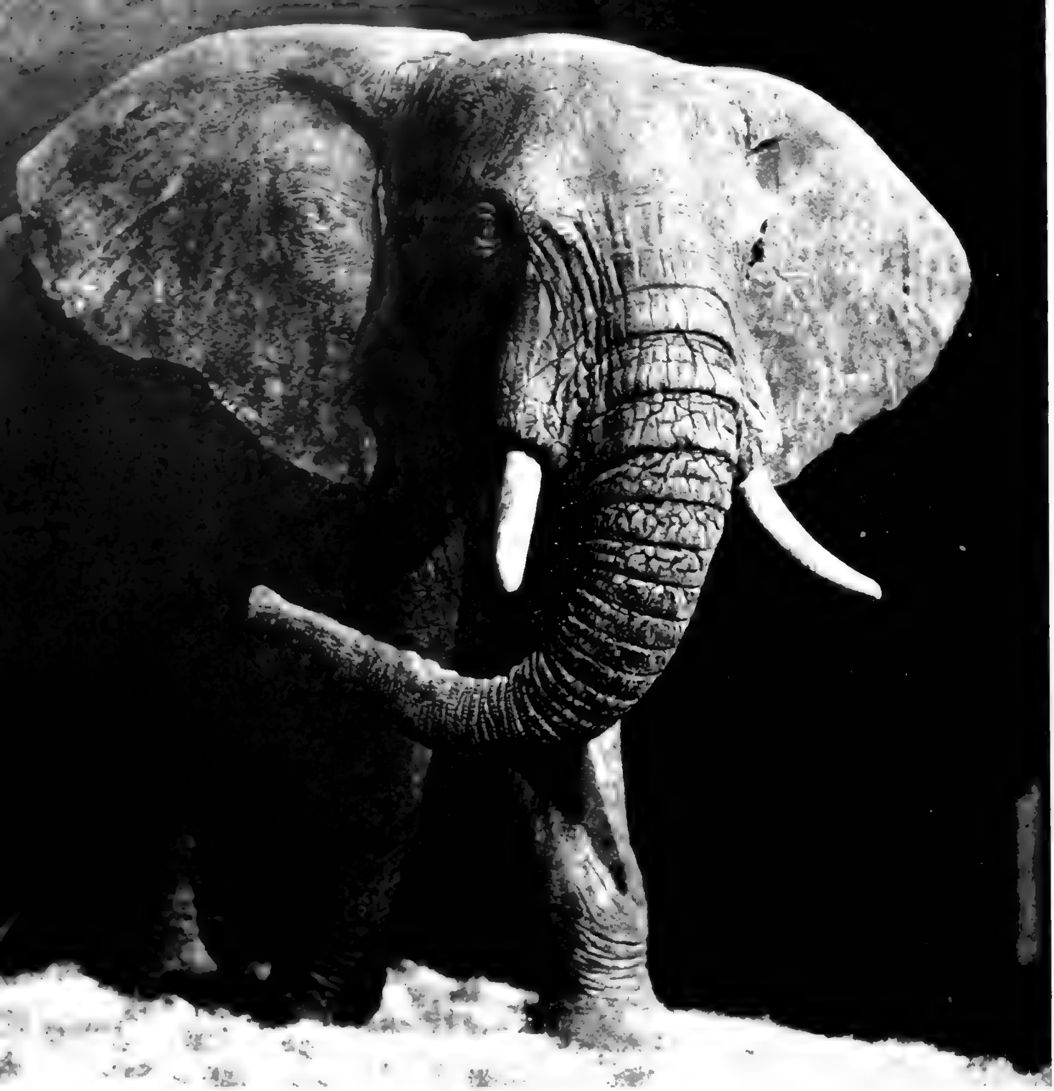
North Gallery, beginning to the right of the entrance (not open as the General Guide goes to press):

GRAY FOX AND OPOSSUM in the Great Smoky Mountains National Park
FISHER AND PORCUPINE near Mt. Washington
RACCOON in Okefinokee Swamp, Georgia
BEAVER in Gladwin Reservation, central Michigan
MOUNTAIN BEAVER in Mt. Ranier National Park
LYNX AND SNOWSHOE RABBIT, Mt. Albert, Gaspe, Quebec
CALIFORNIA GRAY SQUIRREL in Oregon

South Gallery, beginning to the left of the entrance:

ANTELOPE JACK AND BLACK-TAILED JACK RABBIT in cactus country of southern Arizona
BLACK BEAR in cypress swamp in Florida
COTTONTAIL RABBIT in corn field near Ithaca, N. Y.
TIMBER WOLF at night in forest of northern Minnesota
SPOTTED SKUNK AND CACOMISTLE at Shiprock, northern Arizona
COYOTE in Yosemite Valley, California
SKUNK at dusk near Delaware Watergap, N. J.

THE MOUNTAIN GOAT is famous for its climbing ability. The animals in the Museum exhibit reproduced here are shown on a ledge overlooking the Sawyer Glacier in Alaska.



THE REAR GUARD. Detail from the great elephant group in the Akeley African Hall. In every herd of elephants, in the wild condition at least, one animal takes the responsibility of wheeling about at frequent intervals to see that all is well behind. The young male shown above is mounted in this position in the elephant herd. It was collected by John T. McCutcheon in 1910 when he was in the field with Carl Akeley.

AKELEY MEMORIAL HALL OF AFRICAN MAMMALS

The main floor of this hall, entered from the Theodore Roosevelt Memorial Building, was opened to the public in the Spring of 1936. Here are exhibited mammals typical of Africa, in their natural surroundings.

At each side of the door are sculptured representations of African natives by Malvina Hoffman. At the opposite end are a very large pair of elephant tusks.

GIRAFFES AND GAZELLES AT A WATER HOLE.

In the center, dominating the hall, stands a herd of AFRICAN ELEPHANTS in characteristic formation when alarmed. The great bull's trunk is raised to test the air for scent, while a younger bull wheels about to cover the rear of the herd from possible attack.

Immediately to the right of the entrance is the WATER HOLE GROUP. The animals of the plains must come, during the dry season, to such seepage holes to drink. Drawn together by their common thirst are Reticulated Giraffes, Grant Gazelles, Oryxes with long straight horns, and Grevy Zebras. Other typical mammals of Kenya are seen in the background.

Next are the MOUNTAIN NYALA, handsome antelopes, on the heather-covered uplands of Abyssinia.

A herd of AFRICAN BUFFALO emerges from the marshes along the Tana River, Kenya, in late afternoon.

A FAMILY GROUP OF LIONS rests in the shade of a tree, their tawny hides dappled with sunshine. In the background a herd of antelopes and zebras feeds unconcernedly.

The BONGO GROUP show a pair of these boldly striped antelopes in their native bamboo forest high on the Aberdare Mountains, Kenya. They have disturbed another typical forest-dweller, the Giant Forest Hog.

The GIANT ELAND, in the southern Sudan, is the largest of the antelopes.

The UPPER NILE REGION GROUP. Waterbuck, Kob, Nile Lechwe, Tiang Antelope, Situanga, Roan Antelope and Hippopotamus are found together in this exhibit. A tributary of the Nile, showing sunning crocodiles, forms the background.

At the end of a short hallway, there is a large-scale map of Africa, showing localities from which the various animals and their settings were taken.

To the left of the Upper Nile Region Group is the PLAINS GROUP. Here is the teeming mammalian life of the East African plains. The several kinds of antelope and zebra in this group are typical of this part of Africa.

The GREATER KOODOO, the most prized of the twisted-horn antelopes, bears the longest horns of any. An old male, a female and a young male stand in a setting duplicating the rough, scrub-covered hills where these animals were collected.

The GIANT SABLE is noted for its elegant form, deep rich color and long saber-like horns. It is found in a limited area of the dry, park-like country of central Angola and is rapidly becoming extinct.

The GEMSBOK is a larger relative of the Oryx seen in the Water Hole Group. Although once widely distributed in South Africa, the Gemsbok is now common only in dry parts of the Kalahari Desert.

The OKAPI is forest-dwelling and is the only living relative of the Giraffe.

The LIBYAN DESERT shelters such animals as the Addax, with

GREVY ZEBRAS FROM WATER HOLE GROUP IN AKELEY AFRICAN HALL.

AFRICAN BUFFALO. Detail of the group in Akeley African Hall.

THE BONGO is noted for its shyness. Very few white hunters have ever seen a wild one.

GREATER KOODOO GROUP.

MOUNTAIN GORILLA. Of all living animals, the gorilla appears to be most nearly like man. The adult males may reach a weight of 500 pounds. Their strength is tremendous and they are dangerous when enraged. They are found in the rain forests in the highlands of the eastern Belgian Congo. Terrestrial in habit, they feed on fruits and herbage. Details of group in Akeley African Hall.

their spirally twisted horns, the White Oryx, with the scimiter-shaped horns, and the Addra Gazelles.

The GORILLA family is of particular significance because these great apes are among the most man-like of all the living animals. They are shown here in a clearing in the dense rain forest of the Kivu Mountains, an exact replica of their natural habitat.

Gallery of Akeley African Hall

The first group on the right shows the KLIPSPRINGER, the small, rock-climbing antelope in the background. East African Baboons are in the right foreground and a pair of Mountain Reedbuck appears on the left. Among the rocks in the left foreground is a Hyrax or Cony.

A pair of CHEETAH, fast-running cats, closely watches two Nyalas which have just come out of the forest. This setting is in the country near the lower Zambesi River in Mozambique.

A party of CHIMPANZEES is in their tree habitat overlooking the

GERENUK of East Africa is said not to drink even in the well-watered Tanganyika country.

Cavally River, which forms the boundary between the Ivory Coast and Liberia. The animal at the right is in the process of building a nest.

LESSER KOODOO, the males of which have twisted horns, are in company with two Gerenuks – strange, long-limbed, long-necked antelopes with small heads. A flock of Vulturine Guinea Fowl is seen in the background.

A scene from the dense rain forest of the Cameroons shows a group of MANDRILLS looking for food. The females of these baboons are appreciably smaller than the males.

IMPALA prefer the park-like country in which they are shown. With their lithe bodies and lyre-shaped horns, the males rank among the most beautiful of the antelopes.

The WHITE OR SQUARE-MOUTHED RHINOCEROS is miscalled "white" from its habit of wallowing in mud that dries lighter in color. The "square" mouth is an anatomical character. In front of this family group is an African Porcupine.

On the other side of the passage, at the end of which is a large map of Africa, a BLACK RHINOCEROS family enjoys a mud wallow.

A HUNTING DOG pack at evening looks across the plains to where herds of Wildebeests and Zebras can be dimly seen. The dogs rarely

WHITE RHINOCEROS GROUP.

COLOBUS MONKEY. Its long, handsome black-and-white coat suggests a bishop's robe. Actually, it blends with the hanging, light-colored lichens and dark shadows of its forest habitat.

THE LEOPARD GROUP IN THE SOUTH ASIATIC HALL.

SAMBAR ATTACKED BY WILD DOGS.

attack these larger species. Gazelles, Impala, and smaller animals are their usual prey.

The HYENA-JACKAL-VULTURE GROUP. Out on the Serengeti Plains, Tanganyika, a pair of lions have killed a zebra. As they withdraw after completing their feast, the scavengers arrive for their share of the spoils. The animals and birds included in this group are a Spotted Hyena, two Black-backed Jackals, White-backed Griffon Vultures, a Ruppell's Griffon Vulture, two Eared Vultures, a Hood Vulture, a Marabou Stork and a White-collared Raven.

LEOPARDS about to spring upon an unsuspecting BUSH PIG is the subject of the next group. The scene is on the edge of a small swamp in the Aberdare Mountains, Kenya.

The COLOBUS MONKEY GROUP shows a troop of these showy black and white monkeys among the branches of a tree overlooking a section of the Aberdare Mountain Forest, Kenya.

The SOUTH AFRICAN GROUP depicts typical mammals of the high veldt as they were when white men first came there. Springbok are now greatly reduced in number and Blesbok and Black Wildebeest have survived only on a few farms where they are protected.

The OSTRICH GROUP includes a pair of these large birds with young ones just hatched from the eggs. The Wart Hogs would relish the young ostriches but the parents stand guard belligerently.

VERNAY-FAUNTHORPE HALL OF SOUTH ASIATIC MAMMALS

This hall is entered from the left or southern end of the Roosevelt Memorial Hall.

From 1922 to 1928, Mr. Arthur S. Vernay of Great Britain made six expeditions to India, Burma and Siam to collect and give to the Museum this collection. It is considered the finest and most complete exhibit of the larger South Asiatic Mammals in existence.

Two fine examples of the INDIAN ELEPHANT stand in the center of the hall, giving due prominence to the largest and perhaps most characteristic mammal of southern Asia. This species differs from the African Elephant in its smaller ears, higher forehead, and arched back. It also has different teeth and trunk with only one "finger."

The INDIAN LEOPARD differs only slightly from those found in Africa. Both are forest animals but occur in the dry bush country also. They feed on deer, pig, and larger birds such as the peafowl, an example of which has been captured by the Leopard in this group.

The SAMBAR is the largest of the Indian deer, found throughout the wooded part of southern Asia. Its size makes it an important source of food for the larger meat-eaters, but it is powerful and may be dangerous when brought to bay. The Red Wild Dog or Dhole of India hunts in packs, sometimes as many as forty strong. These packs are able to kill animals as large as the Sambar.

The BLACK BUCK is found in the high plains country. The adult male alone is blackish, the females and even young males are yellowish-

THE GAUR. The Gaur is an imposing animal of India, Burma and the Malay Peninsula. It is found in the forests, but sometimes feeds in grassy areas on the high hills. It is not found in the lowlands.

ASIATIC WATER BUFFALO. These buffaloes are the cattle of the grassy plains of India. They are widely domesticated as draft animals and furnish milk to the natives.

THE BANTING closely resembles the Jersey cow in both its rich brown color and its physical appearance. However, the male Banting's coloration blackens with age.

brown. The Chinkara or Indian gazelle also is found in this country.

The MUNTJAC, also called Barking Deer, is one of the most primitive of the true deer. Males have well-developed canine teeth. The antlers are supported on bony structures called pedicels. The Mouse "Deer" or Chevrotain is not a true deer, but is more closely related to the Camels.

The LION formerly had an extended range, chiefly in the plains country of northern India. It is usually pale in color but does not differ greatly from the several races found in Africa.

The FOUR-HORNED ANTELOPE is the only living wild four-horned mammal. It is found in small groups in most wooded and hilly parts of India but not in dense jungle. The Smooth Otter is found south of the Himalaya Mountains in India, Burma and the Malay Peninsula.

The CHITAL or AXIS DEER is one of the most attractive of the deer family. The young of most deer are spotted. This species retains the spotted pattern throughout life. It frequents the bamboo jungle and wooded regions near water and is found in suitable habitats throughout most of India and Ceylon.

The GAUR is perhaps the largest of the existing cow-like animals. Large bulls stand over six feet at the shoulder. The Gaur is found in forested hilly country from India to Indo-China and the Malay Peninsula.

The WATER BUFFALO occurs in the lowlands and swamps of central India, Ceylon and the Malay Peninsula. Buffaloes have been domesticated and used as beasts of burden and milch animals. The wild buffalo is the most dangerous Asiatic bovine to hunt, for it frequently charges without provocation. A herd will attack a tiger without hesitation.

The great one-horned INDIAN RHINOCEROS is characterized by thickened skin which has the appearance of plate armor. Its prehensile, or grasping, upper lip shows that it feeds partly at least on leaves and twigs, although it is found chiefly in the grass-jungles of Assam.

The BANTING is possibly the most like the domestic cow in appearance of all the wild bovines, and may be ancestral to the Indian cattle. It is, however, closely related to the Gaur. It is found in flat country at lower altitudes. The Banting occurs from Burma and Cochin China to Bali in the Malay Archipelago.

The ELD DEER or THAMIN is distinguished from other species by the graceful curve of the antlers in the male. It is found on the river plains and in suitable locations east of the Bay of Bengal, from Assam and Manipur to Cambodia, Hainan, and the Malay Peninsula.

The SUMATRAN RHINOCEROS is related to the Indian species but has two horns and is much smaller. It is found in Assam, Burma, Siam, the Malay Peninsula, Sumatra and Borneo. It is rare and secretive and is found exclusively in forests.

The SLOTH BEAR is characterized by the long flexible muzzle which is used to root termites from their deep runways. These bears feed almost entirely on insects, fruits and honey. They climb trees with difficulty. Sloth Bears are usually timid, but if wounded or cornered, they may be dangerous.

The HOG DEER or PARA is a small relative of the Sambar and is found in the Indo-Gangetic Plain, the flat country in Burma, and much of Indo-China. It is usually solitary in habit.

The INDIAN WILD BOAR is closely allied to the Eurasian Boar but has a higher crest. It is one of the most savage of Indian mammals, fighting until killed.

GIBBONS are the least human of the man-like apes and the most disposed to live in trees. They are capable of walking upright but prefer

THE GIANT PANDA. This interesting creature lives in the bamboo forests growing on the sides of the mountains of western China. Though it resembles a bear in outward appearance, anatomical studies show that it is more closely allied to the raccoon.

SIBERIAN TIGER. From a group in the North Asiatic Hall.

to travel by swinging from branch to branch and from tree to tree. The Hoolock Gibbon inhabits the hills of Assam, Burma, and southern Yunnan. Males are generally black with white brows. Females are often pale yellowish-gray.

The SWAMP DEER or BARASINGHA is related to the Thamin, but differs in the shape of the antlers. It is a large species, preferring to live in the neighborhood of water in open forests and on grassy plains. This group also includes a family of Sambar.

The TIGER is the largest Asiatic cat. Tigers live in the forests and tall grass country, the stripes blending closely with the light and shadow of this habitat. They feed largely on deer and pigs but frequently kill domestic cattle. Individuals too old or decrepit to catch their usual prey may become man-eaters.

NORTH ASIATIC MAMMALS

These may be seen in the circular hall at the end of the South Asiatic Mammal Hall, or through the adjoining Special Exhibition Hall. Eventually, the exhibits will cover the region north of the Himalayas, including Tibet, Afghanistan, Mongolia and Siberia.

Two groups are now completed – THE GIANT PANDA GROUP and the SIBERIAN TIGER GROUP. Material for the third, or SAIGA ANTELOPE, incomplete, is laid out in one of the cases.

Until such time as other groups are planned and completed, the remainder of the hall is given over to the Corner Gallery, where temporary exhibits of current interest are displayed.

THE HALL OF OCEAN LIFE

Leading from the Hall of Fishes is the Hall of Ocean Life. In it are displayed whales, porpoises, marine mammals, the great CORAL REEF GROUP and marine invertebrates.

"Oscar," the whale embryo, is shown in the vestibule of the hall, opposite the shell of a great clam.

Immediately upon entering the hall, the visitor will note the large skeletons and models of whales and porpoises suspended from the ceiling. In the corner, at the left of the entrance, is a model of the WHITE WHALE, a large northern porpoise. Just in front of the entrance to the hall is the striking full-size model of the KILLER WHALE, with contrasting black and white markings. The Killer Whale is a fierce hunting animal, capable of swallowing a fur seal or small porpoise at a gulp. Near the Killer and facing it hangs the model of a BLACKFISH, which, like the Killer, is a species of giant porpoise, although milder in disposition. Skeletons of these animals are below the models.

Above the balcony in front of the entrance is suspended a life-like model of a GIANT SQUID, a great backboneless sea animal upon which the Sperm Whale preys. The large skeleton to the right is that of a SPERM WHALE, the largest of the living toothed whales. The Sperm Whale was formerly most sought by whalers as the source of spermaceti, a white, brittle, fatty substance found in the sperm-oil in the head of the whale. It was used in making candles and in salves and ointments. Beyond the Sperm Whale, on the same side, hangs a skeleton of the FINBACK WHALE.

Just above these two large skeletons are found skeletons of the NARWAHL and species of toothed whales, including several rare types. At the near end of this row is a Sperm Whale model, and at the far end a small model of the SULPHUR-BOTTOM WHALE, the largest animal in the world.

Along the left side of the hall, three skeletons of whales are hung. The one nearest the entrance is a RIGHT WHALE, the middle one a

SKELETON OF THE ATLANTIC RIGHT WHALE. The "whalebone" is shown in the skeleton suspended from the roof of the mouth as close-set, horny plates.

HARPOONING THE SPERM WHALE DURING THE DAYS OF SAILING SHIPS. One of a series of murals in the Hall of Ocean Life depicting whaling in olden times when sailing vessels were used and the whales were captured with a harpoon thrown by hand.

PYGMY RIGHT WHALE, and the third a CALIFORNIA GRAY WHALE. Above them is a long row of life-like models of whales and porpoises, ranging in species from the Right Whale and the Common Dolphin to the rare River and Lake Dolphins.

About the center of the row is a model of the PYGMY SPERM WHALE. At the far end are two large models, one of the spectacular NARWHAL with long ivory tusk (at the right), the other the FALSE KILLER, formerly a very rare species, but in recent years appearing unexpectedly off the British Isles and the coast of South Africa, where a large number were stranded in shallow water.

Around the walls of the balcony are eleven murals. Along the right side are four great paintings showing scenes typical of AMERICAN SPERM WHALING and titled respectively "The Chase," "The Attack," "Towing the Carcass," and "Trying Out." On the left wall are three canvases portraying the life of TYPICAL SPECIES OF WHALES, including "Bowhead Whale," "Finback Whale," and "Killer Whales Attacking a Gray Whale." These seven murals are the work of Mr. John P. Benson, the noted marine painter.

The walls to the right and left of the entrance bear murals by J. M. Guerry: left, the Sulphur-bottom Whale; right, Sperm Whale with its favorite food, the Giant Squid.

Below the level of the balcony and hanging just beyond reach from the rail at the head of the stairway is a cast of a YOUNG SPERM WHALE which came into New York Harbor and was eventually made captive in the Gowanus Canal in Brooklyn. It was brought entire to the Museum.

On the main floor of the Hall of Ocean Life and under the balcony are the habitat groups of marine mammals. Beginning at the near right

A BULL WALRUS FROM THE PACIFIC WALRUS GROUP IN THE HALL OF OCEAN LIFE. One of the specimens secured by the Stoll-McCracken Expedition to Bering Sea. Group presented by Mrs. Andrew Carnegie.

A FAMILY OF FUR SEALS. Details from a group in the Hall of Ocean Life.

A toy-size antelope, Swayne's dik-dik is a close relative of the Giant Eland which weighs 1200 pounds: one of the many interesting exhibits in the Synoptic Hall.

corner, the first of these is the group of NORTHERN ELEPHANT SEALS, huge, ponderous animals that have hauled themselves out on the rocky beach of Guadaloupe Island, Lower California. The full-grown male of this species has a long, hanging proboscis suggestive of an elephant's trunk. Next is the exhibit of the FLORIDA MANATEE, a thick-set beast, well-adapted to its life in the water.

The PACIFIC WALRUS, one of the largest groups in the Museum, shows these Arctic sea mammals at home on an ice floe in the Bering Sea.

In the first left corner is a large group of STELLER SEA LIONS on St. George Island, one of the Pribilofs. The male Sea Lions are huge, powerful seals with massive necks and shoulders.

Many details of the home life of the beautiful ALASKA FUR SEALS, on Kitovi Rookery, St. Paul's Island, may be noted. Each vigorous, dominant bull has his harem of sleek, slender cows, while nearby are the bachelor bulls and the playful pups.

On the floor of the hall are several cases with special exhibits. One of these is the TOWNSEND FUR SEAL, a species almost extinct and only recently rediscovered after it was believed by many to have disappeared completely. Another case displays several types of diving gear with full equipment of pump, telephone, etc.

SYNOPTIC HALL OF MAMMALS

This hall, entered from the Insect Hall, chiefly illustrates various interesting differences in the habits and structures of mammals. It also shows their principal orders and the main subdivisions of these, known as families. Each family is, as far as possible, represented by a mounted specimen and a skeleton.

Starting from the farther or western end and walking around the room from left to right, one passes from the egg-laying Platypus to

Man, represented by the figure of an Australian native, armed with a boomerang.

Certain exhibits demonstrate modifications of form and structure for various ways of locomotion, and the superiority of the brain of mammals over that of other backboned animals. Others show albinism (white varieties) and melanism (black varieties). Still others point out that animals outwardly similar may be only very distantly related. How the coat of the hare changes from brown to white and how plants and animals adapt to a desert habitat are also illustrated.

Of special note is the SKELETON OF JUMBO, the largest elephant ever brought to this country alive.

The FRUIT BATS, often known as FLYING FOXES, the largest member of the bat family, and found only in the warmer parts of the Old World, are represented by a small portion of a colony from Calapan, Philippine Islands. Such a colony may be very destructive to bananas and other fruits.

The most striking object in the hall is the suspended life-size model of a SULPHUR-BOTTOM WHALE, seventy-six feet long. The original of this specimen was captured in Newfoundland and the model is accurately reproduced from careful measurements. This species of whale is not only the largest of living animals, but, as far as we know, the largest animal that has ever lived. A specimen of this size would weigh from sixty to seventy tons, twice as much as the extinct reptile BRONTOSAURUS. Although whales and porpoises live in the water, they are not fishes but true mammals, since they are warm-blooded, breathe by means of lungs, not gills, and nurse their young with milk.

MAMMALS OF NEW YORK STATE

A complete series of the living mammals which have been known to exist within the limits of New York State is presented in the corridor on the first floor of the Roosevelt Memorial in the neighborhood of the elevators. This exhibit includes skins and skulls of all mammals of moderate size, models of the larger species, and cutout figures of the whales and other large sea-animals recorded from the water around New York.

ANIMAL BEHAVIOR

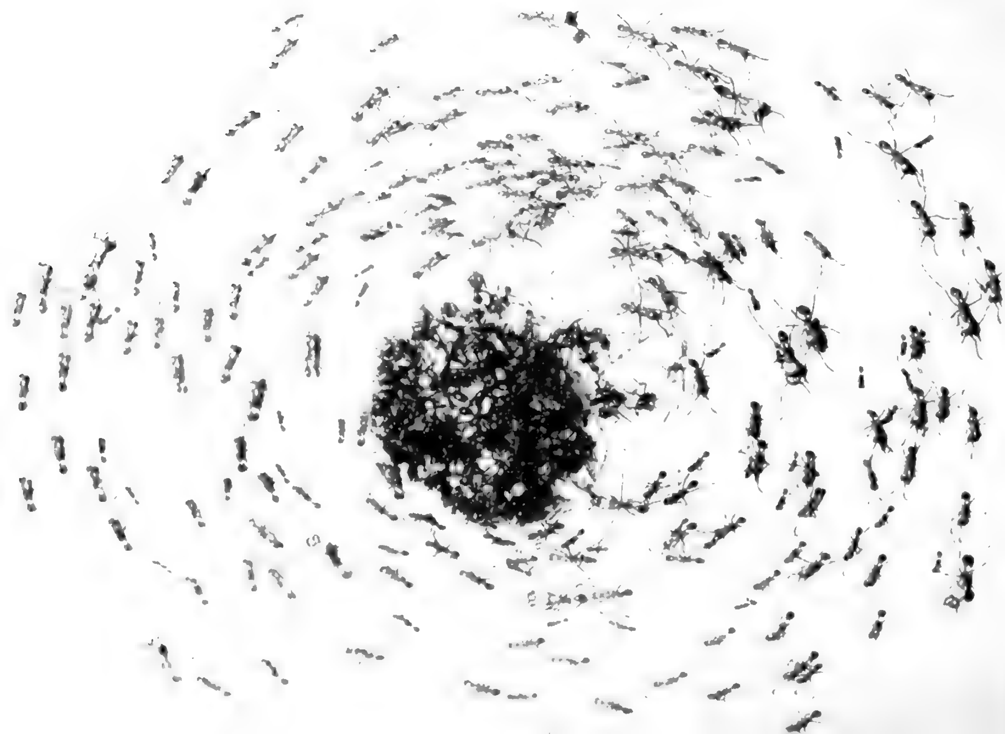
Most visitors are unaware that the Museum also houses a large laboratory devoted entirely to the study of LIVING animals. This is the Department of Animal Behavior which is located on the sixth and seventh floors of the African Wing. Although this area of the Museum is not open to the general public, special science groups are taken through the laboratory when advance arrangements are made. In this way hundreds of advanced students from New York City High Schools as well as college classes have visited the laboratory in recent years and for many, this was their first opportunity to see a research laboratory in operation. The staff of the Department is also available for consultation when important problems concerning animal behavior arise.

About two decades ago, Museum authorities in their deliberations concerning Museum policy decided that while a major function of this institution continues to be the census, classification and structure of animals, attention should also be paid to the relationship of the various animals to each other and to their surroundings. Museum scientists should investigate and exhibit not only what animals do, but also how and why they behave as they do. Thus the Department of Animal Behavior was established so that specialists in the psychology and physiology of animals could study these aspects of natural history, and could be available for consultation particularly in the planning of new exhibits.

Much can be learned by the scientist when he observes how animals behave in their natural surroundings. However, this approach to animal study has very definite limitations. It is generally difficult in a field study

AFRICAN MOUTHBREEDING FISH SPAWNING IN LABORATORY AQUARIUM. The female is laying eggs in the "nest," as the male stands by ready to fertilize them. Within a minute after the last egg is laid and fertilized, the male will pick up these eggs and carry them in his mouth until they develop into young fry.

A CIRCULAR COLUMN OF WORKER ARMY ANTS IN A LABORATORY NEST. Under natural conditions, these ants carry out their daily pillaging raids on complex systems of branching chemical trails. Excited by the presence of active larvae, the workers in the laboratory enclosure also move incessantly, but now in a circle. Once such an endless column is formed, the workers may run in it more or less continuously for several days, until all are dead from dryness.



A SIMPLE TEST OF PARENTAL BEHAVIOR IN THE RING DOVE. For a considerable part of the incubation and nesting period in this bird, the nest locality and the nest itself are attractive to the parents, whereas eggs or young alone are not. In this test the parent bird, removed from the nest, was presented with the young on one side and the nest on the other. Brushing past the young without pause, the adult returned directly to the nest and proceeded to sit in it.

to rearrange the surroundings so that a given aspect of behavior can be studied reliably. Laboratory study offers an opportunity to follow up, to supplement or to correct ideas developed in the field. Also many important problems must be brought into the laboratory if they are to be studied at all. For example, some species of fish live in water so muddy that they can be seen only when the seine brings them to the surface. They can be collected in the field, but their way of life remains hidden except to laboratory study. For reasons such as these, the Department of Animal Behavior has a laboratory designed to keep animals alive and in good health, so that their behavior can be observed and analyzed under suitable conditions. A large greenhouse situated on the

roof has aquaria for warm water fishes and facilities for other tropical animals. There are flight cages and nest quarters for birds. There are rooms with controlled lighting so that animals can be placed in reversed daylight cycles and thus nocturnal species can be studied during the daytime. There are special air-conditioned and heat-controlled rooms and other means of regulating laboratory surroundings to meet the conditions needed for each type of animal and problem.

The Departmental program is focused upon the important problem of behavior development in the individual and species and upon those types of behavior commonly referred to as "instinctive." Physiological mechanisms involving brain, nerves, glands, and hormones are studied along with social factors, previous experience and finally the general influence of an animal's surroundings upon its behavior pattern. All of these affect the animal's behavior to some extent, and the question is "how." Somewhat as the evolution of animals is reflected in changes from simple to more complex structures, we find among animals an evolution of behavior from the forced movements characteristic of one-celled forms to the elaborate behavior patterns characteristic of mammals and man. For a proper understanding of the evolution of behavior it is necessary to study a variety of behavior patterns in very different animals. Thus as the Departmental program progresses, living quarters are provided for many types of animals under study, usually including insects, fish, amphibia, birds and various species of mammals.

ANTHROPOLOGY

MAN AND HIS ORIGINS

Anthropology is both a natural and a social science dealing with the complex subject of man as a physical being and also with man's culture — what he does and thinks.

That branch of the science concerned with man as an organism is known in this country as physical anthropology. This includes the evolution of man, the classification of the varieties and races of man as he exists today and has in the past, and various aspects of human biology.

Anthropology, as a social science, has been concerned chiefly with the development and meaning of culture. There are two principal branches: archaeology and ethnology.

The archaeologist works with the tools, buildings, and other objects left by ancient peoples and attempts to reconstruct the history of human culture from the time of its origin through the many thousands of years preceding the periods for which we have written records.

The ethnologist studies and compares the varieties of customs and beliefs of the existing peoples of the world. Both are primarily interested in understanding the nature of human culture — that which can be defined as the body of knowledge, beliefs, customs or ways of doing things which are passed along from generation to generation by the informal or formal processes of education.

Only by knowing the varied forms that the cultures of man have attained and something of their changes throughout time can we fully understand the unique creature which is man.

HALL OF PRIMATES

The Systemic Series of Primates, intended to give some idea of the types of animals included in this order, and their range in size, form, and color, begins on the left with examples of gorillas and chimpanzees and is

THE FIRST FOUR STAGES FROM FISH TO MAN. (From water-living to land-living)

Stage 1
Primitive Ganoid Fish
(Cheirolepis)

Stage 2
Lobe-Finned Fish
(Eusthenopteron)

Stage 3
Generalized Amphibian
(Diplovertebron)

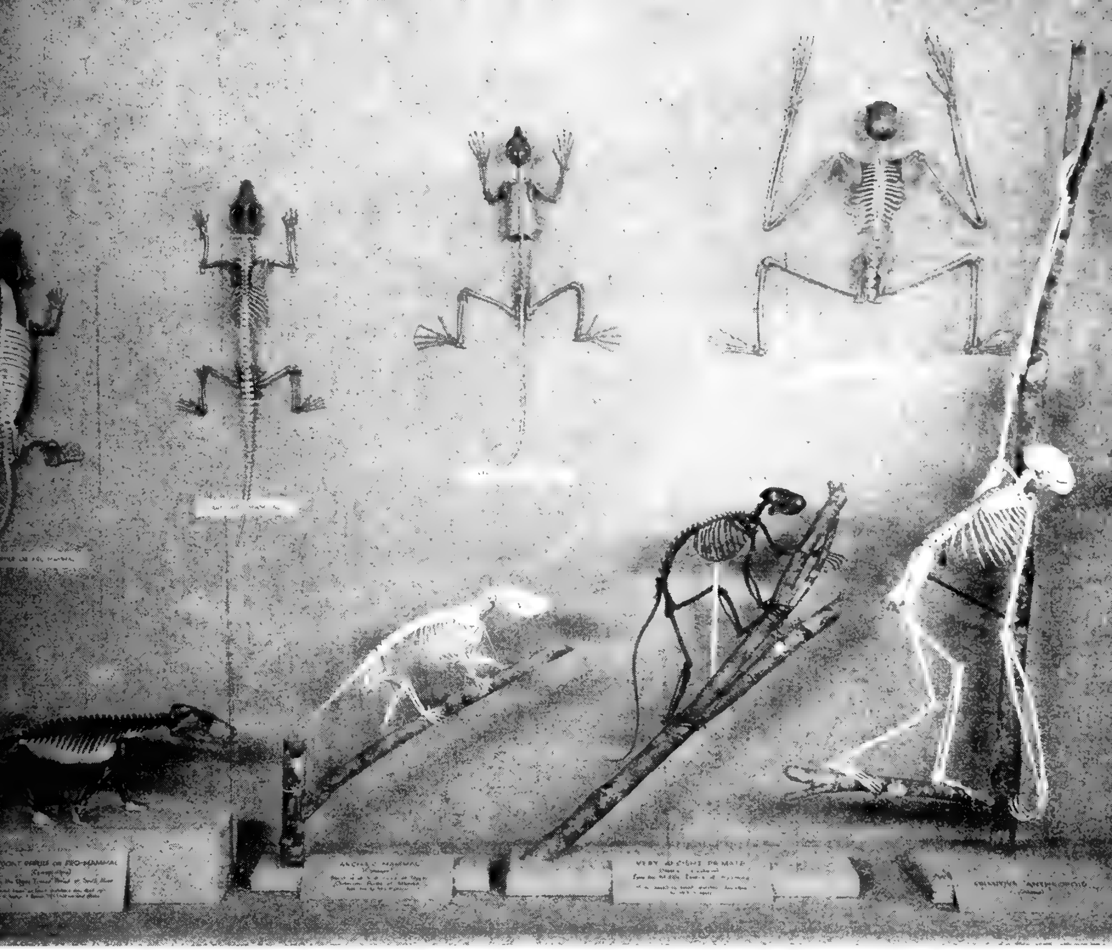
Stage 4
Primitive Reptile
(Seymouria)

continued in the wall cases around the room, ending with the lemurs. Noteworthy among the primates is the gorilla, largest and most powerful of apes; the curious "proboscis" monkey from Borneo; and the aye-aye of Madagascar.

The center corridor contains groups of primates characteristic of various parts of the world – Africa, Asia, South America and Madagascar, and a group of human pygmies living in the forest of central Africa.

Outside of the central corridor, on the left side of the hall, is a group of orangutans from Borneo.

At the farther end of the hall, a series of skeletons demonstrates the comparative structure of the primates and the changes that take place in passing from lemurs to man.



THE SECOND FOUR STAGES FROM FISH TO MAN. (From ground-dwelling to tree-dwelling)

Stage 5
Cynodont Reptile or Pro-Mammal *(Cynognathus)*

Stage 6
Archaic Mammal Oppossum

Stage 7
Very Ancient Primate *(Notharctus)*

Stage 8
Primitive Anthropoid Gibbon

HALL OF THE NATURAL HISTORY OF MAN

The Hall of the Natural History of Man consists of two parts — Introduction to Human and Comparative Anatomy, and the second part dealing with the physical characteristics of the Races of Man, Development, Growth, and related topics.

The first part begins by showing MAN IN HIS COSMIC ASPECT, with man conceived as a living engine which derives its working capital of energy directly or indirectly from the energy of the sun stored up in plant and animal tissue. This energy is appropriated by man in food substances and distributed through the various anatomical systems.

In another exhibit the ELEMENTS OF THE LOCOMOTOR APPARATUS in backboned animals are set forth. It is shown how red

THE TWO FINAL STAGES FROM FISH TO MAN. **(On the ground again, and attainment of erect posture)**

Stage 9
Anthropoid Ape (Chimpanzee, above; Gorilla, below)

Stage 10
Man

muscle fibers of the fish are combined into W-shaped muscle segments or myomeres and how the muscles of man are constructed.

Other exhibits deal with the anatomy of man as compared with lower backboned animals, following the chief organ systems of the body and the parts concerned with locomotion.

The POSITION OF MAN AMONG THE VERTEBRATES and the evidences of his evolution from lower backboned types are shown by comparisons of skeletal structure in living and in fossil types, and by comparisons of his muscle system with lower forms, as well as by comparative embryology. An analysis of the nervous system, and the evolution of the human brain are dealt with, and the functions of the brain are demonstrated.

The second part of the exhibit, on the right side of this hall, is devoted to EXHIBITS ILLUSTRATING HUMAN BIOLOGY. Shown are exhibits of the growth and development of a human embryo, skeletal growth in the head, and the variety of physical types of man as modified by glandular secretions. A series of full-size figures showing some of the major racial types of man has been placed in the central alcove.

Two charts are also displayed in this alcove. One illustrates the natural habitats of the various racial types exhibited. The other depicts the major population movements throughout the world since 1492.

At the far end of this side of the hall will be found an exhibit on some of the more important endocrine functions.

The Skeleton from Fish to Man

The judgment of science is that our pre-human ancestors only reached the grade of humanity after many millions of years of evolution from lower to higher grades of life.

Owing to the enormous number and variety of organisms in nearly all geologic ages, and to the wholesale destruction of their skeletons by natural agencies, only a small number of the fossil forms which we have discovered to date happen to lie in or near the direct line of ascent from fish to man. Nevertheless, the story of the evolution of the skeleton from fish to man is clear in its main outlines as shown in this exhibit.

The FIRST STAGE represents the earliest true fishes by a model of a fish in the early stage of evolution of higher bony fishes. This fish, which breathed by gills in the normal fish way and which perhaps had a simple air-sac or lung, must have looked something like a trout, but its tail was more like that of a shark. The body moved forward in the water by a wriggling movement caused by the contraction of the regularly arranged muscle segments along either side of the body. The axis of the body was an elastic rod called the notochord, similar to that which appears in the embryonic stages of all higher backboned animals, including man. The fins were composed of rays serving as keels and rudders.

The SECOND STAGE represents a long step in advance. It is based on a fossil fish named Eusthenopteron, from the Upper Devonian of Canada. This fish still had gills but there is some evidence that it also possessed an air-sac or lung. It had two pairs of paddles, corresponding to the fore and hind limbs respectively of four-footed land animals.

The THIRD STAGE, from the Carboniferous Age, represents the oldest known type of four-footed animals. The skeleton of the hands, feet and limbs is much more developed than in the previous stages. There are five digits on each of the hands and feet.

The FOURTH STAGE represents the primitive reptilian or lizard-like stage from the Lower Permian of Texas. The skeleton on the whole is not greatly different from the preceding stage, except in detail, but the limbs are better developed.

The FIFTH STAGE represents an advanced mammal-like reptile *(Cynognathus)* from the Upper Triassic of South Africa. In this form the

limbs are better adapted for running, and there are many features of the skull, backbone, and limbs that approach the condition in mammals.

For the SIXTH STAGE the skeleton of a modern opossum is used. It retains in the main the leading characters of the skeleton of the older fossil mammals. This form has five-toed grasping hands and feet, by means of which it climbs about in the trees. It has kept a relatively low type of skull, teeth, and brain.

In the SEVENTH STAGE we come to *Notharctus,* a form that lies near the lower limits of the order of primates to which man belongs. These animals were thoroughly adapted to life in the trees but they had much larger eyes and bigger brains than any of the preceding stages.

The EIGHTH STAGE is represented by the skeleton of the gibbon, an East Asiatic ape which is a tree-living descendant of the first family of the tailless or man-like apes. When on the ground it is the only existing man-like ape which normally walks on its hind legs. Its skeleton begins to be almost human in many ways but the arms are excessively long.

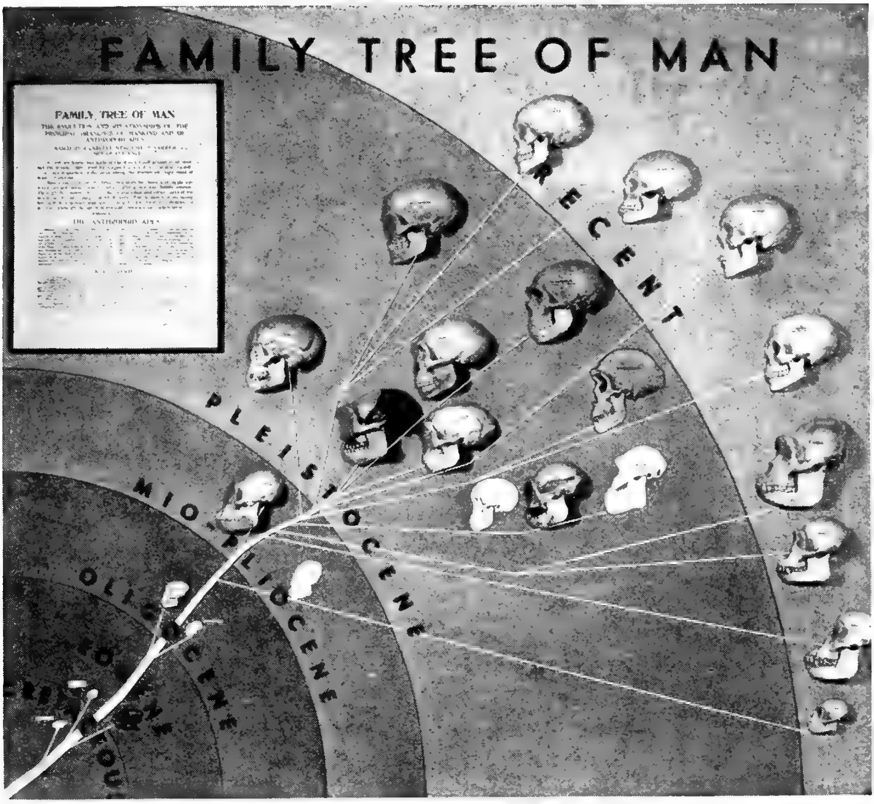
The NINTH STAGE is represented by our distant cousins, the gorilla (below) and the chimpanzee (above). These apes retain the essential characters of fossil apes from India and South Africa, some of which approached quite near to the oldest known fossil men. The ape brain is much more developed than the brains of lower animals, and ape intelligence at times is almost human.

In the TENTH STAGE, we see that the human skeleton is built on the same general plan as that of the chimpanzee, gorilla, and gibbon, but that in man the backbone, pelvis, and limbs are modified to enable him to walk on his hind legs and to use his forelegs as arms and hands rather than as supports. His brain is much larger and more highly developed than in the apes.

OSBORN HALL OF THE AGE OF MAN

This hall is devoted to early man and his contemporaries, the mammoths and mastodons, and the giant ground sloths of South America. The visitor learns what is known of the early history of our own race as shown by the remains of early man and the implements he used. As fossil remains of man are rare and usually very fragmentary, these are represented mainly by casts, but they include examples of all of the more perfect and noteworthy specimens that have been found, from *Pithecanthropus* and *Sinanthropus* to NEANDERTHAL and CRO-MAGNON.

In the surrounding cases are some of the principal skeletons and skulls of animals mostly of the Pleistocene Age (see Time Chart on p. 51) known to have been associated with man especially in North and South America. Skeletons and skulls on the right side of the hall show the evolution of the Proboscidea. They fall naturally into two groups: first, the mastodons; and second, the mammoths and elephants. In the former division, beginning near the entrance of the hall, are the most primitive mastodons, with two upper and two lower tusks, and a very



THE FAMILY TREE OF MAN. The evolution and relationships of the principal branches of mankind and of anthropoid apes.

short proboscis. The succeeding cases show the gradual reduction of the number of teeth and the shortening of the front part of the skull for the accommodation of the longer proboscis found in all of the later stages of mastodons and mammoths.

On the left is a group illustrating the famous asphalt trap of Rancho la Brea at Los Angeles, California, and fossils from South America, the most striking of which is the group of giant ground sloths. There are also good examples of gigantic relatives of the armadillo, the glyptodonts or "carved-toothed" animals.

Among other strange extinct animals are the camel-like MACRAUCHENIA, and the rhinoceros-like TOXODON. These evolved in South America during the Age of Mammals when it was an island continent as Australia is today.

On the walls are mural decorations painted by Charles R. Knight, showing the typical groups of Pleistocene animals of North and South America and Europe that were associated with early man.

In the HALL OF THE NATURAL HISTORY OF MAN we see models of various skulls, ranging from the earliest Primates of the Eocene Period, through the monkeys and apes of the Miocene and Pliocene, to the subhuman and human races of the Pleistocene and Recent ages.

The exhibits in the central aisle of the HALL OF THE AGE OF MAN deal mainly with the older races of mankind as shown by their fossil remains and by preserved fragments of their handiwork.

MEN OF THE STONE AGE. Here we see a representation of the newly discovered *Australopithecus* of South Africa, a skull cast of Trinil, or Java "ape-man," and skeletal remains or cases representing Peking Man, Piltdown Man, Heidelberg Man, Neanderthal Man, and Cro-Magnon Man. An excellent series of sculptured restorations of these types, four of which are illustrated below, have been made and are generally considered as embodying the most recent scientific deductions as to the general appearance of these primitive races of mankind. The earliest of them takes man back at least to the lower Pleistocene, estimated at 1,000,000 years ago.

Weapons and implements of rough and polished stone and of bone are exhibited as evidence of the gradual building-up of human culture through the "rough stone" and "polished stone" ages of Man's prehistoric period. Reproductions of the cave paintings of Cro-Magnon man in France and Spain show the artistic ability of the early stock which first represents modern man in Europe.

A series of mural paintings by Charles R. Knight over the doorways of the Hall of the Age of Man gives a vivid idea of the various races of early man as seen by the artist in harmony with our best scientific knowledge.

The HALL OF PREHISTORIC CULTURES on the second floor also exhibits the early arts and industries of the European Cave Men and Lake Dwellers, as well as North American prehistoric men.

RESTORATIONS OF HEAD AND SHOULDERS OF EARLY MAN. These restorations were made by Professor J. M. McGregor following scientific principles and utilizing the skull-remains of the various types as a starting point. They are as follows:

1. Trinil Ape-Man *(Pithecanthropus erectus)*
2. Piltdown Man *(Eoanthropus dawsoni)*
3. Neanderthal Man *(Homo neanderthalensis)*
4. Cro-Magnon Man *(Homo sapiens cromagnonensis)*

USES OF BIRCHBARK AMONG THE EASTERN WOODLANDS INDIANS. (From a miniature diorama in the Woodlands Indians Hall)

LIVING RACES OF MAN

The Woodlands Indians

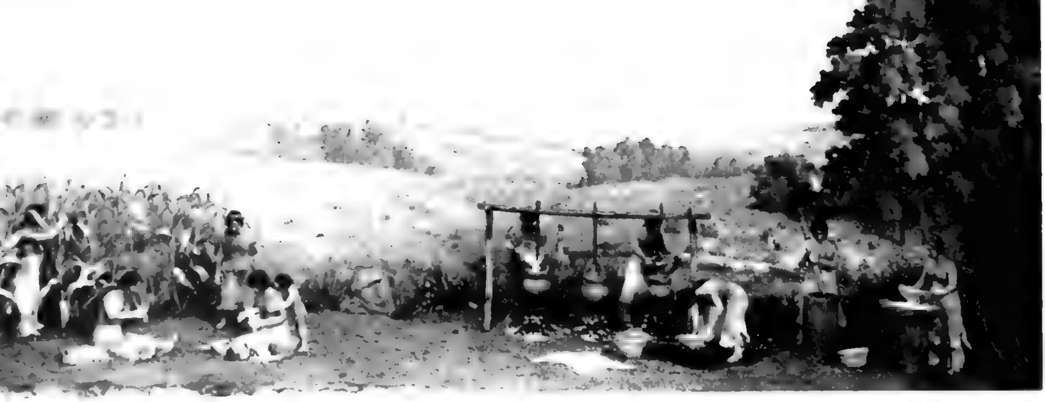
Walking to the left on entering the Museum from 77th Street, we meet first the Indians of New York and New England. The successive exhibits are so arranged that the visitor can imagine himself traveling across the United States from east to west.

Although called the Eastern Woodlands Indians Hall (northeastern United States and Canada), the exhibits in this hall include the Southeastern and Mackenzie culture areas, the former joining the Eastern Woodlands on the south, the latter on the northwest. The whole Eastern Woodlands area was in forest and reached westward from the Atlantic coast to the Mississippi River. Objects on display show that these Indians lived in the forest. The materials they used came from the forest, and this fact influenced their houses, tools, weapons, clothing, and ornaments, so that they are readily distinguished from those of other areas.

These forest Indians were primarily hunters and fishermen but they also ate wild rice and maple sugar. They grew corn, beans, squash, tobacco and other plants where the climate allowed. (See miniature dioramas at north side of hall.) Their woodland environment led to simple industries dependent upon the raw materials that were at hand and adaptable to their daily needs.

Wood was used for canoes, mortars, spoons, bowls, dishes, houses and wood splint baskets. Bark of various kinds was a favorite material. For example, the birchbark industry is illustrated not only by a diorama but by containers and ornaments in many of the cases. Bark like that of the basswood tree was also shredded to make the fiber for weaving bags.

Skins were originally used for costumes, but, since the Woodlands area was one of the first regions of North America to be influenced by European contact, cloth was often bought from white traders. Many wild plants and trees furnished fiber from which these Indians made good string and cord for making fish-nets and for weaving bags. Every well-equipped house required mats for the floor and for sleeping.



EASTERN WOODLANDS AGRICULTURE. A miniature diorama showing the Iroquois Indians of New York State clearing the land and tilling the soil.

THE NATCHEZ INDIANS OF MISSISSIPPI. The Natchez were well-organized socially, advanced in pottery making, weaving, and agriculture. The chiefs possessed unusual powers and were carried in litters. Large temples were built upon mounds of earth.

THE SEMINOLE INDIANS OF FLORIDA. (From a miniature diorama in the Woodlands Indians Hall)

Climate influences the ways of life. In this hall, the tribes represent a range from near-Arctic Canada to sub-tropical Florida. Their clothing varies from fur garments among the Dene and the Cree, to thin dresses of commercial cloth among the Seminole.

A number of miniature groups along the side walls and in the cases show tribal costumes, housing and industries. Especially interesting subjects are rock shelters, the making of rabbit skin clothing, weaving with basswood fiber, making a false face, and the stages by which corn is made into bread.

Travel was on foot. Dugout or bark canoes were used in summer where streams or lakes were accessible. Snowshoes were used in winter, and in the north the toboggan was common.

The dwellings of this area are of several forms. Among these are the long rectangular houses of the Iroquois covered with oak bark, the dome-shaped huts of Long Island and vicinity which were covered with mats and bundles of grass, and the familiar cone-shaped wigwam of the Ojibway covered with birchbark. The utensils are of pottery, wood or birchbark. Pottery was made by most of the Eastern tribes and seems to be associated with farming. The designs are cut in, cord-marked, or paddle-stamped, but never painted.

Bowls, trays and spoons are made of wood and are often decorated with animal carvings. The use of birchbark in making light household vessels is one of the particular traits of our Eastern Indians.

These Indians invented canoes, maple sugar, tobacco pipes, cornhusk weaving, splint baskets, tump-lines or devices for carrying heavy loads, wampum, the game of la crosse, netted snowshoes, the toboggan and the water-drum.

The Indians' history begins with the landing of white men. Many of the objects shown in the cases are historic, but others, such as the stone, bone and shell objects found in the ground, are usually prehistoric. In the exhibits dealing with Manhattan and Staten Island, from which the Indians were driven by the first settlers, we can show nothing but pottery, stone, bone and shell objects. These local relics will be found near the entrance to the hall. On the left are some pottery vessels and many small objects made of stone and bone from Manhattan Island, Staten Island, Long Island, and Westchester County. Nearby, on the same side of the hall, are collections obtained from living Indians of the coast region north and south of New York. These are the Penobscot and Passamaquoddy of Maine, the Micmac and Malecite of the lower provinces of Canada, and a few rare objects from the Delaware who once occupied the vicinity of New York City and the State of New Jersey. The age and historical relations of these cultures are shown in a large label at the left of the entrance.

A family group of Micmac Indians, in a birchbark cone-shaped house, is shown half way down the hall.

On the opposite side are the Iroquois, whose league included the Mohawk, Seneca, Oneida, Onondaga, Cayuga, and later the Tuscarora.

They dominated New York and much adjoining territory. The exhibits represent particularly the agriculture of the East, which was carried on with rude tools by the women.

In the farther end of the hall, on the left, are the collections from the Ojibway, who lived mainly north of the Great Lakes. They had but little agriculture, living chiefly by hunting and fishing and the gathering of wild rice. Beyond the Ojibway are the Cree, who lived farther north.

Opposite the Ojibway are the great Central Algonkin tribes, the Menomini and Sauk and Fox, as well as the Siouan Winnebago, who lived south and west of the Great Lakes. They too gathered wild rice and hunted and fished and also did some farming.

In the southeastern portion of the United States, agriculture was highly developed. These tribes are represented by the Cherokee and Yuchi, who made pottery, and by the Choctaw and Chitimacha, who made fine baskets of cane as well. The Seminole of Florida, though long influenced by the white man, have maintained an independent existence in the Everglades for nearly a hundred years. Their prehistoric arts are illustrated in the table case. They excelled in polishing stones and working shell. (See the diorama on the north wall.)

The Plains Indians

When we think of Plains Indian life, we think of such terms as "tipi," "buffalo," "horse," and large decorated "pipes." The tipi and the pipe are especially conspicuous in the center of the hall.

The art of these Indians is highly original and popular. Painting on skin is the usual method, but many designs in beadwork and quills are shown.

Artists look upon the feather headdress of these Indians as the most beautiful type of headdress to be found anywhere in the world. With this and his highly decorated costume, the Plains Indian is a colorful figure.

Indians of the Plains made up the tribes living west of the Mississippi and east of the Rocky Mountains as far south as the valley of the Rio Grande and as far north as the Saskatchewan.

Beginning on the left, the buffalo-hunting tribes: the Plains-Cree, Dakota, Crow, Blackfoot, Gros Ventre, Arapaho and Cheyenne, occupy the greater part of the hall. These tribes did not farm but depended almost entirely on the buffalo. They ate the buffalo and used its skin to make their clothing. Sometimes a buffalo paunch was used for cooking, and horns were made into various tools and weapons. The spirit of the buffalo was thought to be a powerful ally and was called upon to cure sickness, to ward off evil, and to give aid in the hunt. Wherever the buffalo herds led the way, the more nomadic Plains tribes moved their tipis and followed. When most of the buffalo were wiped out, the entire life of the Plains Indians was revolutionized.

On the right, near the entrance, are the village tribes of the Plains: the Mandan, with whom Lewis and Clark passed the winter of 1804-1805;

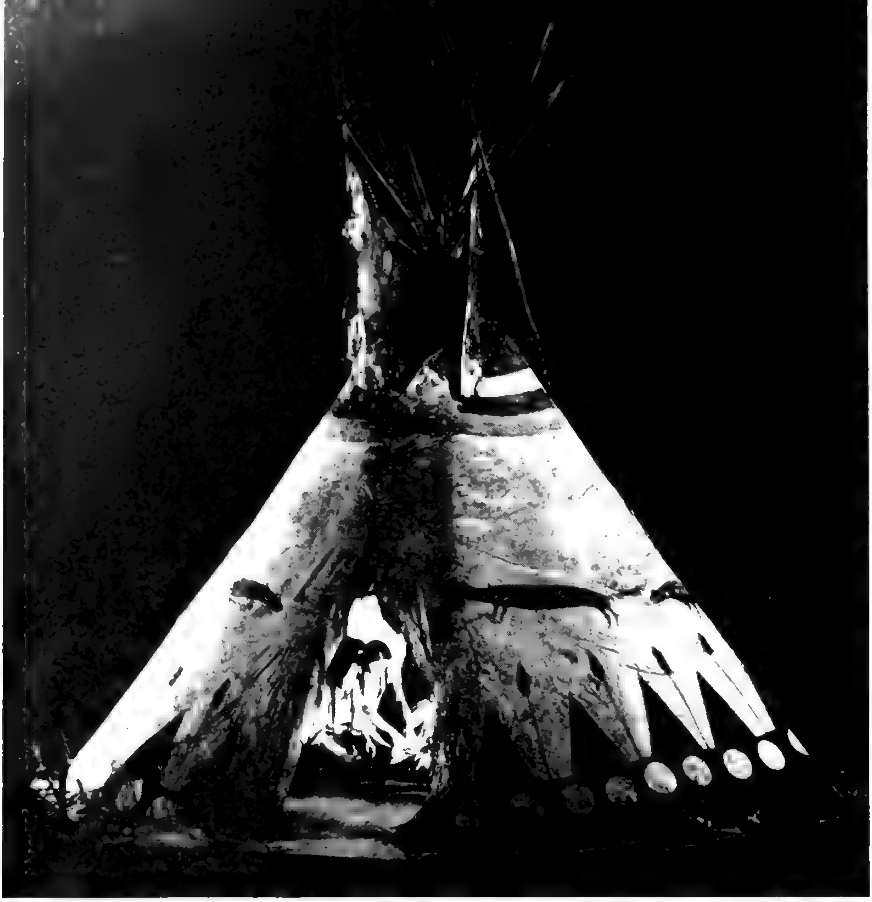
A DAKOTA WARRIOR.
(Model in Plains Indians Hall)

A DAKOTA WOMAN.
(Model in Plains Indians Hall)

the Hidasta, who now live with them; and the Omaha, Kansa, Iowa, and Pawnee. All these tribes raised corn and lived in large earth-covered houses. A small model of one of these houses stands near the exhibits.

In the center of this hall is a Blackfoot Indian tipi with paintings of otters on the sides, representing a vision of the owner. This tipi has been fitted up to show the home life of a typical buffalo-hunting Indian.

There were numerous soldier societies among the Plains Indians which included practically all the adult males. Each society had a special dance and special costumes. (See the Arapaho cases for costumes of dancers.) There were other dances connected with tribal religious ceremonials, the best known and most important of which is the Sun Dance, shown by a model at the left of the tipi. The Sun Dance was held yearly



A BLACKFOOT INDIAN TIPI. The interior has been furnished with full scale models showing typical Plains Indian life of the nineteenth century.

AN HIDATSA EARTHLODGE. A section of this model has been cut away to show the interior. Houses of this type were used formerly by most of the semi-agricultural tribes of the Plains.

in the early summer to keep a vow made the winter before by some member of the tribe who wished a sick relative to recover. The dance involved self-torture, great physical endurance and a fast lasting three days.

In the center of the hall is a medicine pipe, held in awe by the Indians and dearly parted with; also the contents of a medicine bundle. The contents of another medicine bundle, belonging to a leading medicine man of the Blackfoot tribe, together with the headdress which he wore in ceremonies, are in a case near the tower. Other remarkable bundles, particularly the skull bundle, are in the Pawnee case on the north wall.

The Plains Indians are noted for their painted buffalo robes and for their quillwork, which was superseded by beadwork when glass beads became available in historical times. They have a highly developed decorative art in which simple geometric designs are the elements of composition. This is one of the most interesting features of their art. (See Dakota case.)

Indians of the Southwest

This region is famous for two reasons: its picturesque living Indian tribes, and the large number of ruins built by prehistoric Indians. Since many of the latter are placed upon high rocks or in the walls of canyons, they are spoken of as Cliff Dwellings.

This hall presents collections from both the prehistoric and the living Indians of the Southwest. On the right are the nomadic or wandering tribes: the Apache, Navajo, Pima, Papago, and Havasupai. A life-size exhibit, the first of a series along the right-hand wall, shows the home life of the San Carlos Apache. Next is a larger group showing a Navajo hogan in Canyon de Chelly, and the Night Chant ceremony. The painted background of this group gives a view of the canyon, and in a cave of its walls one may see the famous White House ruins.

Navajo silverwork and blankets are shown in nearby cases. The Navajo are the modern blanket makers. They card, spin and weave the wool of the sheep they raise with simple implements and looms. This art has arisen since the coming of the Spaniards and it is known to have passed through several stages in the last sixty years. Some of the older types of blankets shown here contain yarn which was gotten by cutting or raveling from imported flannels, called in Spanish "bayeta," from which these blankets get their name. These are either bright red or old rose in color, resulting from cochineal dye. Several blankets are made of yarn bought ready-dyed from traders and are called Germantowns. The greater number, however, are made of yarn of native spinning, dyed with native vegetable and mineral dyes.

The Navajo are a large and widely scattered tribe. During the winter they live in log houses, but in milder weather they camp in the slight shelter of a cliff or windbreak and shade made of brush. They live by raising corn in the moist valleys, and on the flesh of their many flocks of sheep.

The Western Apache live along the upper portion of the Gila and Salt Rivers, where they farm, gather natural products and hunt. Indians related to these, under Geronimo, raided the settlements of southern Arizona and northern Mexico and evaded our troops for years. They live in grass-thatched houses or in the open under the shade of flat-topped opened-sided shelters.

The Eastern Apache lived in buffalo skin tipis. They went far out on the plains in search of the herds, avoiding, if possible, the Plains tribes, but fighting them with vigor when necessary. In dress and outward life they resemble the Plains Indians, but in their legends and ceremonies they are like their Southwestern relatives and neighbors.

In the first alcove to the right of the entrance is a basketry exhibit showing the types of baskets and the materials, tools, and techniques used by the Southwestern tribes. This exhibit is in contrast with the corresponding case of pottery on the opposite side. Not the environment, but social habits, caused one people to develop pottery and the other to make the easily carried and not easily breakable baskets.

At the left of the hall, as we enter, are exhibits for the modern village Indians — first types of pottery from San Ildefonso, Laguna, Santo Domingo, Zuni, and Hopi.

A NAVAJO MEDICINE LODGE. For the celebration of the Navajo Night Chant a special house is erected. The medicine man is laying down an elaborate ceremonial sand-painting. Group in Southwest Indian Hall.

HOPI SNAKE DANCE. This is given on alternate years by the Snake and Antelope priests in all but two of the Hopi villages to insure the rain needed for the crops. (From a miniature diorama in the Southwest Indian Hall)

The Pueblo Indians live in large community houses, built of stone or adobe, often with several stepped-back stories. They depend chiefly on farming for their food, make a great variety of pottery, and have many elaborate religious ceremonies. The nomadic peoples live in tipis or small brush and thatched houses which are moved or deserted when they are forced to seek the wild game and wild vegetable products which furnish much of their food. They make baskets for household purposes which are more easily carried than vessels of clay. In the hall are models of the pueblos of Taos and Acoma, of prehistoric cliff-dwellings, and of the houses used by the Navajo.

The inhabitants of Zuni are believed to be the descendants of the first people seen by the Spaniards in 1540. Their former villages, many of which are now in ruins, were probably the "Seven Cities of Cibola," for which Coronado was looking at that time. Although there were missionaries among them for about three hundred years, they have kept many of their own religious ceremonies. Many ceremonial objects, as well as those of everyday life, are shown in this alcove.

In the Hopi section are costumes, masks, images, and basketry plaques used in their ceremonies. Their best known ceremony is the Snake Dance, supposed to increase rainfall and the crops. Some of the regalia worn for the Snake Dance are shown, as well as a small model of a single phase of the ceremony. In the center of the hall a table case shows a Hopi altar, of the type that figures in nearly all Hopi ceremonies.

In the center of the hall, as well as in the farther half of the left side, are special exhibits for the prehistoric Indians of the Southwest. Near the center is an exhibit showing how many prehistoric ruins have been dated by the tree-ring method. A chart at the entrance to the hall gives the successive culture periods for the Southwest, beginning with early Basket Makers and ending with the modern Pueblo villages. Typical objects made by the Basket Makers are shown in small cases in the center of the hall and in upright cases to the left.

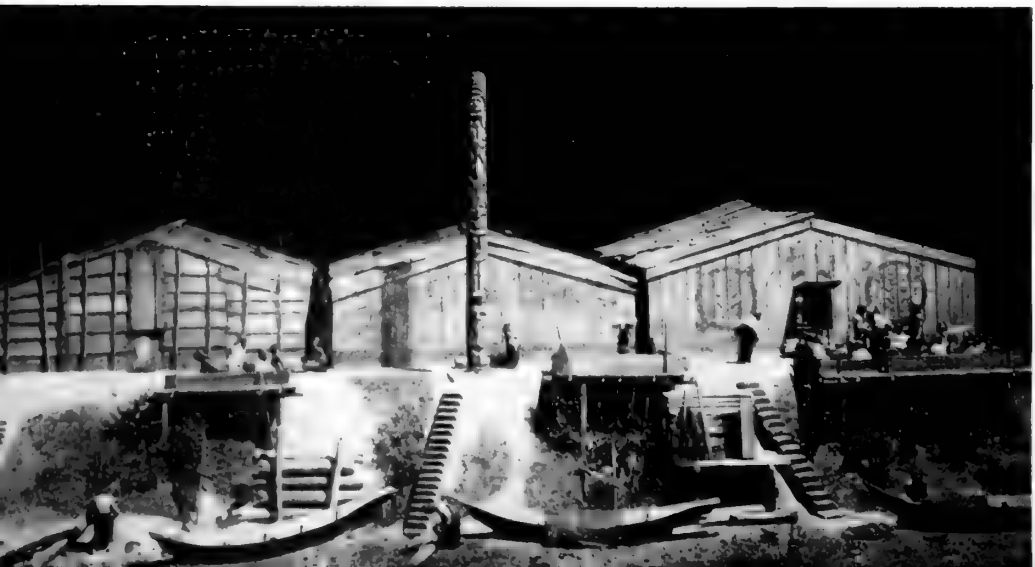
Two of the most famous prehistoric Southwestern ruins are Bonito and Aztec. A model of the latter stands in the center, and near the entrance is an exhibit of turquoise from Pueblo Bonito. Other collections from these two ruins are shown in cases at the left of the hall. One contains a remarkable collection of pottery from Pueblo Bonito. Similar black-on-white wares with very elaborate and splendidly executed designs, shown in adjacent cases, are from Rio Tularosa, and in part from cliff-dwellings. In another case is found material gathered by the Museum expedition which explored the Galisteo Valley, New Mexico.

Other exhibits in this area illustrate the culture of the living Indians of California. Most outstanding of the achievements of these tribes was their basketry, some examples of which are among the finest produced in the world.

Indians of the North Pacific Coast

The Jesup North Pacific Hall is devoted to the Indians living in the heavily forested and mountainous coastal belt extending from the Columbia River in Washington to Mt. St. Elias in southern Alaska, as well as on the offshore islands. They are the most skillful wood workers on the American continent, as shown by the models of their houses; their intricately carved and painted totem, house, and grave posts; their ceremonial masks, boxes, implements, and tools. They depended on their forest environment for housing, clothing, and utensils and they depended on the products of the sea for food. Travel and transportation were mainly by water and they skillfully hollowed out giant cedar logs for canoes like the large Haida war canoe in the center of the hall.

MODEL OF A KWAKIUTL VILLAGE, VANCOUVER ISLAND, showing plank houses facing the sea with canoes drawn up on the shore. Crests of the owners are painted on the walls of houses and carved on the house posts in front.



A PIPE carved in the form of a whale by the Tlingit Indians of Alaska.

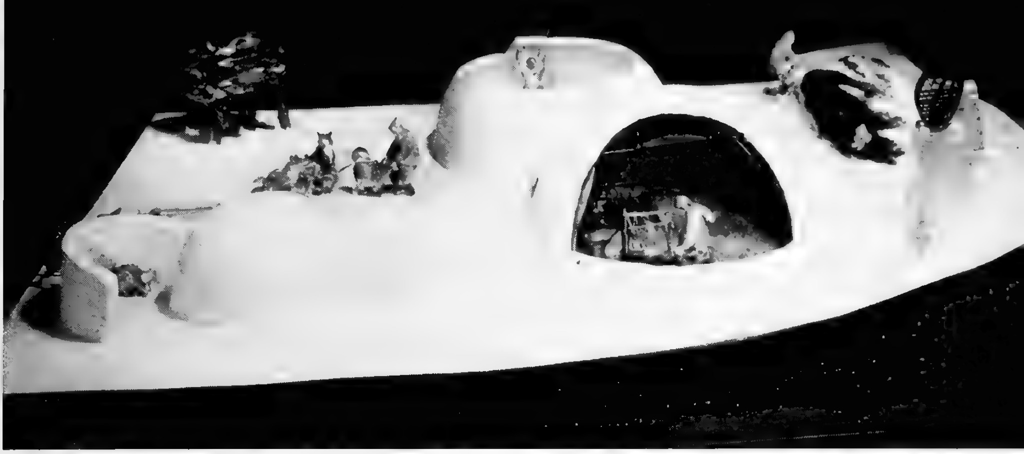
Except for two tribes, the Shuswap and Thompson, who live in the interior of British Columbia, the exhibits are arranged in the order in which the various tribes are encountered in going from south to north along the coast of Washington, British Columbia, and Alaska. On the right side of the hall are the Bella Coola, Tsimshian, Haida; on the left, the Nootka, Kwakiutl, Tlingit.

The murals of Will S. Taylor depict not only the industries, religious and social life of these Indians, but also their heavily forested and fog-and-rain-drenched environment. The murals on the right side show ceremonials and religious life. On the left they show daily life and industries. Games are illustrated over the entrance and at the farther end of the hall, the return of a victorious war party.

They were also skilled in weaving with mountain goat wool and shredded bark and in making baskets. Notice the Chilkat ceremonial blankets a little over halfway along the hall, on the left, and the Tlingit baskets at the end. These Indians have likewise distinguished themselves in the carving of stone, bone, and ivory, examples of which are shown for the various tribal groups.

Outstanding perhaps is the wealth of decoration seen on all their products. The typical grotesque art motifs, based on the distortion of animal forms, are found in equal abundance on useful and ceremonial objects.

ESKIMO WOMAN FISHING THROUGH THE ICE. (Group in the Eskimo Hall)



MODEL OF AN ESKIMO WINTER HOUSE, CUMBERLAND SOUND. The side of one house has been cut away to show interior. Outside are the dogs, dog sled, and the storage racks for meat.

Eskimo

The Eskimo are often named as the primitive people who have made the most complete adjustment to their environment. They inhabit the northern shores and neighboring islands of North America, from easternmost Siberia and the Aleutians to East Greenland and Labrador. All these Eskimo, who differ somewhat in details of culture according to locality, are represented here, though not with equal completeness.

Contact with the white man has changed the Eskimo's way of life, but he continues to use many of his traditional tools, implements and distinctive articles of fur clothing. The Eskimo are hunters and fishermen. In summer they hunt the caribou, musk ox and birds, often inland. Their dwellings at this season are tent-like frames covered with caribou or seal skin.

In winter they hunt sea mammals, especially seals. Their winter houses are of stone built over shallow excavations and are covered with earth. The familiar snow house is the traditional winter dwelling of certain tribes but is unknown in Alaska and in most of Greenland. Models on exhibit show how the snow house is built. The Eskimo are skilled in the making of fur clothing and skin boats. The clever implements they make of wood, bone and ivory are often decorated with naturalistic cut-in designs. Many of the objects shown here are from the collections made by the Peary, Comer, MacMillan, and the Stefansson-Anderson expeditions.

Near the entrance of the corridor is an Eskimo woman fishing through the ice. She has made a windbreak with ice blocks. The fishing rod and hook and the long ladle are made of bone. She keeps the water from freezing while she is fishing by using the ladle to break and remove ice. In another case an Eskimo woman is cooking inside a snow hut that is lined with seal skin. She is using a stone lamp filled with seal oil which provides the flame for her cooking.

Indians of Mexico and Central America

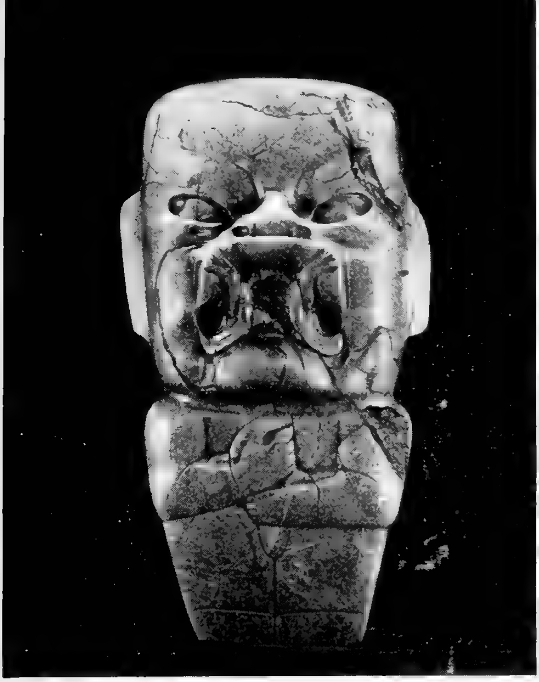
At the west stairway on the second floor, we enter an alcove and a hall devoted to the ancient civilizations of Mexico and Central America. The alcove contains a series of small dioramas showing the varieties of climate and landscape in Middle America, a large series of gold and jade objects, and pottery vessels typical of several of the culture areas into which Middle America can be divided.

Entering the central part of the main hall, one faces a cast of a gigantic stone head of the Olmec culture. Along the sides of the central portion are reproductions of some of the great carved monuments of the Maya sites of Copan and Quirigua, and a series of cases containing a number of the more beautiful objects in the Museum's collections.

Four of the alcoves along the right side of the hall are given over to each of the four major cultural periods in the history of the Valley of Mexico, the others to the Central Vera Cruz area, the Huastec area, the Maya, and the cultures of El Salvador and Costa Rica.

The left side of the hall deals with Western and Northern Mexico, with the cultures of Oaxaca and with a number of the major sculptured monuments of the Aztec of Central Mexico. The far end of the hall is Mayan, with several models of Maya buildings and two large cases

AZTEC CORN GODDESS. This outstanding example of Aztec stone sculpture is notable for its simple naturalistic presentation. It was found in Ixtapalapa, a town near Mexico City.



OLMEC STYLE CEREMONIAL AXE IN GREEN JADE. One of the largest and finest Olmec jades known, this is one of the great treasures of the Middle American collection.

containing examples of Maya sculptures. These original pieces are from Copan and from Northern Yucatan, the latter being all that remain from a collection made by John Lloyd Stephens, the "discoverer" of the Maya civilization early in the last century.

The walls and landings of the west stairway between the first and third floors exhibit reproductions of various Maya and Central American sculptures.

CULTURES REPRESENTED: The material represented in this hall shows the history and cultural accomplishments of some of the more civilized peoples of the New World, sometimes referred to as those of Middle America or Mesoamerica. Within this area there were many local cultures, but all of them had characteristics in common which set them off as a unit distinct from the somewhat less highly developed cultures of North America, and both the lesser and higher cultures of South America. Several distinctive features of the Middle American cultures are the use of lime mortar in building and the existence of complex calendar systems and hieroglyphic or picture writing.

The higher Middle American cultures lasted for a period of nearly 3,000 years, so time is an important factor in any consideration of them. The following basic time schedule is generally applied:

15,000 B.C.-1,000 B.C. – *Period of Early Man.* Only meager remains of this earliest period have yet been discovered in Middle America, most important being the skeleton of Tepexpan Man, estimated to date from 10,000 B.C. No materials from this period are on exhibit.

1,000 B.C.-1 A.D. – *Pre-Classic Period.* Variously known as the

Archaic or Middle Culture Period, this is represented by peoples living in permanent villages depending on farming, but without the great ceremonial buildings of later periods. Pottery-making and sculpture in clay were important.

1 A.D.-900 A.D. – *Classic Period.* This is the great period of Middle American civilization, taking in the so-called Old Empire of the Maya and the Teotihuacan, Zapotec, and Totonac cultures of Mexico proper. It is the period of the great cities and many of the sculptured monuments shown in the hall.

900 A.D.-1520 A.D. – *Post-Classic Period.* With the close of the Classic Period, new and seemingly more militaristic orders were established, represented by the New Empire or Mexican Period in Yucatan and by the succeeding Toltec and Aztec dominations of Central Mexico. The period ends with Cortez's conquest of Mexico and the almost complete destruction of the native cultures.

SCALE MODEL OF MAYA TEMPLE. The temple on top of a high pyramid at Tikal, Guatemala, is shown here in miniature. This is one of a number of architectural models on display.

GOLD LIP PLUG. This extraordinarily fine ornament is attributed to the Mixtec culture of Oaxaca in southern Mexico.

NATURE OF OBJECTS. It is impossible to present a well-rounded picture of the ancient Middle American civilizations, for, with rare exceptions, it is only the more lasting objects of pottery, stone, bone, shell and metal that have survived the destructive action of time and weather. Such things as the wooden drums of the Aztec are therefore great treasures. However, in our attempt to understand the life of ancient Middle America, we can rely heavily on the small number of native manuscripts in picture-writing that have been preserved and on the remarkably full accounts of native life written by the early Spaniards.

ARCHITECTURE. The varied and imposing architecture of Middle America may be seen in the models and illustrations distributed around the hall. The buildings preserved are either temple structures built on pyramid-like platforms or are thought to be housing for the priests or persons concerned with the elaborate religious ceremonies. Ornate tombs are also important, the full-sized reproduction of one at Monte Alban being a good example of this architectural form. Little remains, and nothing is shown, of the ordinary living quarters, as these were apparently of wood or thatch, similar to those in use at the present time and just as impermanent.

SCULPTURE. It is in sculpture that we may best measure the tremendous attainments of the ancient peoples of Middle America. Their religions with their many gods required many images shown in a great variety of human and animal forms. These are often grotesque and hard for us to appreciate, but they are usually conceived according to universally accepted standards of beauty and high artistic quality. An early and important style is that seen in the Olmec sculptures, which range from the most delicate of jade carvings to the colossal stone head from southern Vera Cruz, mounted in the center of the hall. In the Olmec style, the human figure is presented with a suggestion of Negroid features, often in combination with those of the jaguar, an animal that

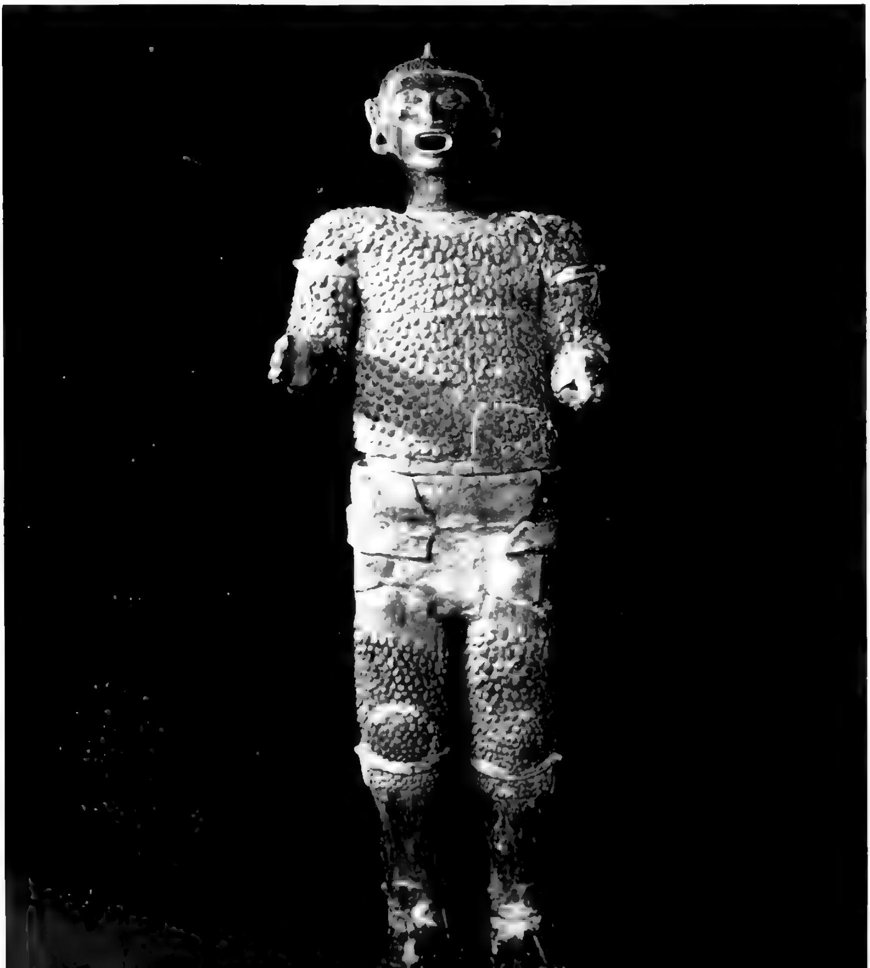
played an important role in the symbolism of the early cultures. It is curious that the Olmec carvers, who seem to represent one of the earliest of the high cultures of Middle America, were the greatest masters in the carving of jade and produced sculptural forms most readily appreciated by us.

Maya sculpture is more complex and appears to reflect an involved religious belief and ritual. The great skill of the native sculptors is apparent in the Copan and Quirigua stelae or tall stone slabs, where intricate detail is combined with the handling of enormous masses. Our respect for these ancient peoples is further increased when we realize that these great works were done without the benefit of metal tools.

Many and varied figures in baked clay also show a great technical and artistic ability. Especially interesting is the historical series of figurines from the Pre-Classic and Teotihuacan horizons of the Valley of Mexico. The succession of styles has been used by the archaeologist as a sensitive marker of culture change.

WRITING AND THE CALENDAR. The highest developments of the art of writing in the New World were attained by the Maya. A number

THE GOD XIPE-TOTEC. This life-sized image of terra cotta shows the wearing of the skin of a sacrificial victim. From near Texcoco, across the lake from Mexico City, the figure dates from the Toltec period.



MAYA CORN GOD. From the great Maya center of Copan, Honduras, this life-size stone figure is certainly one of the great masterpieces of Maya sculpture. It dates from the latter half of the Classic Period when Maya art and architecture saw its highest development.

of examples of their picture-writing are found on the reproductions of the stelae and on other objects in the hall. A major portion of these texts concerns the statement of dates in the elaborate calendrical system brought to highest perfection by the Maya, but also used by the Zapotec, Aztec and other groups. However, most of the non-calendrical parts of the Maya texts remain undeciphered. Both the Maya and the Mexican peoples also painted their hieroglyphics in books of paper or leather known as codices. Only a few still remain from Pre-Conquest times.

POTTERY. Vessels of baked clay are abundant in all collections from prehistoric sites in Mexico. Their interest is two-fold, in giving us a knowledge of the daily life of the native peoples and as one of the most important measuring devices in the study of the history of our

OLMEC WOODEN MASK. This is a unique specimen, being the only wooden object known from the Olmec culture. The sensitive sculpturing of the mouth portion is partly hidden by several remaining pieces of a jade mosaic and by a gummy substance used to hold the mosaic in place.

area. The modern archaeologist relies to a large extent on the broken pottery found in the kitchen middens or refuse heaps of living sites. By carefully excavating and analyzing the changes in pottery types from the lower to the higher levels in these refuse heaps, he is able to estimate the changes of styles and of peoples through time and from area to area. An example of this method of reading history by examination of pottery layers is shown in the Huastec alcove on the right side of the hall.

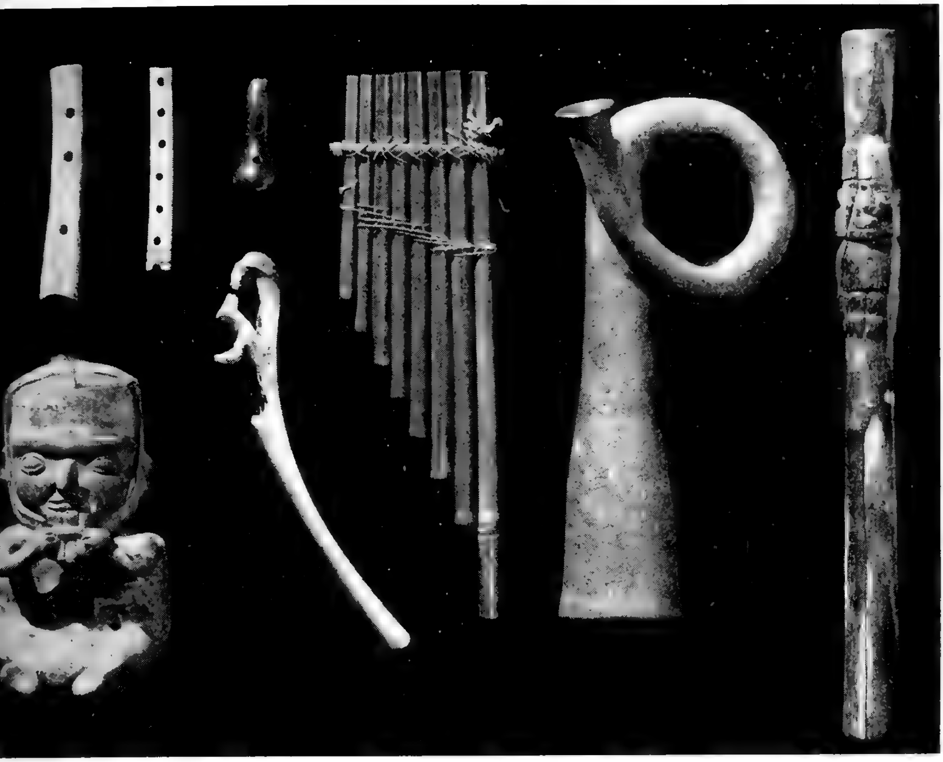
METALS. The use of metals appeared late in Middle American history — at the beginning of the Post-Classic Period. The techniques of metal-working occur much earlier in South America and it is assumed that these arts were diffused northward into Middle America. Nevertheless, the gold-work of Mexico is considered to be of higher technical and artistic quality than any other in the New World.

JADE. Various kinds of semi-precious stones were used in Middle America for ornament or insignia, but jade was the substance most highly prized. The Middle American jades are classified as jadeite, but are distinct from the Asiatic types. Several styles of jade carving are recognized, the finest being those of the Olmec and the Maya, of which outstanding examples are to be seen in the alcove to the left of the entrance to the main hall.

CAST OF OLMEC STONE HEAD. The original of this gigantic stone head lies in the jungle in southern Vera Cruz at the Olmec site of San Lorenzo. It is nine feet in height and weighs an estimated 15 tons.

MAYA POTTERY BOWL WITH CARVED DECORATION. A fine vessel from northern Yucatan dating from late in the Classic Period.

CARVED SLATE MIRROR BACK. The elegant design and the curvilinear motifs around the edge of the disc place this piece in the so-called Tajin culture of central Vera Cruz. It is probably late Classic in date.



MUSICAL WIND INSTRUMENTS OF ANCIENT PERU. The wind instruments of the ancient inhabitants of Peru, as illustrated above, included the panpipe or syrinx shown in the center; resonator whistles (left); trumpets of clay and wood; and a great variety of simple whistles. The pottery figure at lower left shows how the panpipe was played.

Indians of South America

This hall contains Indian exhibits from all the South American countries except Uruguay. The largest portion of the exhibits illustrates the prehistory of the peoples of Peru and Bolivia and is arranged in the front of the hall.

Unlike the ancient peoples of Mexico and Central America, the Peruvians had no written language. They were tillers of the soil and raised potatoes, oca, quinoa, beans, coca and cotton. They domesticated the llama as a beast of burden and the alpaca as a source of wool. They excelled in the manufacture and decoration of pottery vessels, in metal work and in textiles.

Their gold and silver objects, such as beads, cups, pins, plates and ear ornaments, show a high degree of skill in the beating, soldering and casting of metals.

In weaving, the Peruvians were perhaps first among prehistoric peoples of the world, many of their textiles shown here being unsurpassed to

the present day. The materials used were cotton and the wool of the llama, alpaca and vicuna. In the cases near the entrance are examples of these textiles and the fibers, spindles, threads, looms and other equipment used in their manufacture. At the center of the hall are beautiful examples of fabrics decorated with feathers. Some of the costumes in use at the time of the Conquest are displayed at the right of the entrance hall. To the left are complex embroideries made by the people of Paracas before the beginning of the Christian era.

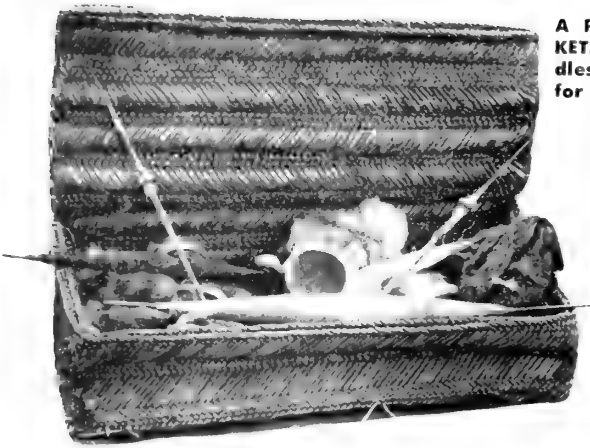
On the right side of the hall are collections from important localities in Peru, followed by exhibits from Ecuador, Colombia, Venezuela, Brazil and Panama. In Case 57, near the center of the hall, selected pieces of pottery show the different forms and decorations which distinguish the various important cultures of Peru and Bolivia. As far as our present knowledge permits, the changes which occurred in the course of time are also indicated. Each of these cultures is shown in greater detail in individual cases.

Outstanding is the beautiful work of the Nazca people who excelled among all American potters in their use of color. This display is arranged to show the wide representation of mythological creatures, birds and animals, with one section devoted to the differences which distinguished two separate traditions in their motifs.

POTTERY OF THE MOCHICA OR EARLY CHIMU PERIOD. A warrior in full regalia is depicted on the vessel at the left. In his right hand he holds a mace; in his left, a shield, spear thrower, and javelins. The central piece is a "portrait" jar. The vessel at the right shows a hand to hand combat between mythical beings.

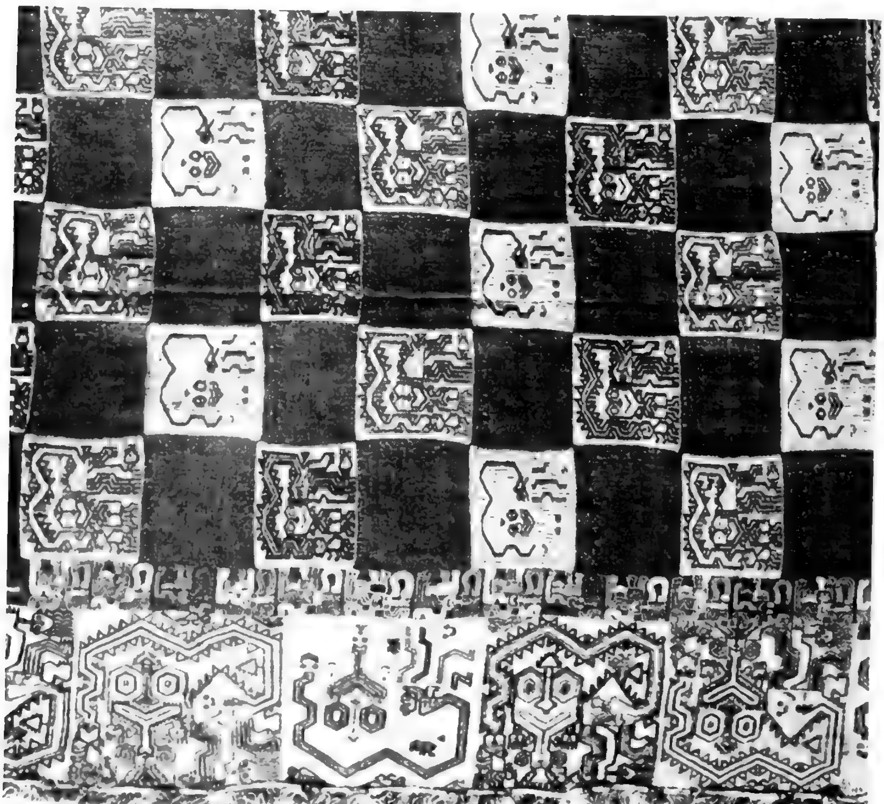
NAZCA POTTERY. By far the most skillful use of color in Peruvian ceramics is seen on such specimens as these. As some of the mythological beings depicted also appear on earlier Paracas embroideries a cultural continuity of the two periods is indicated.

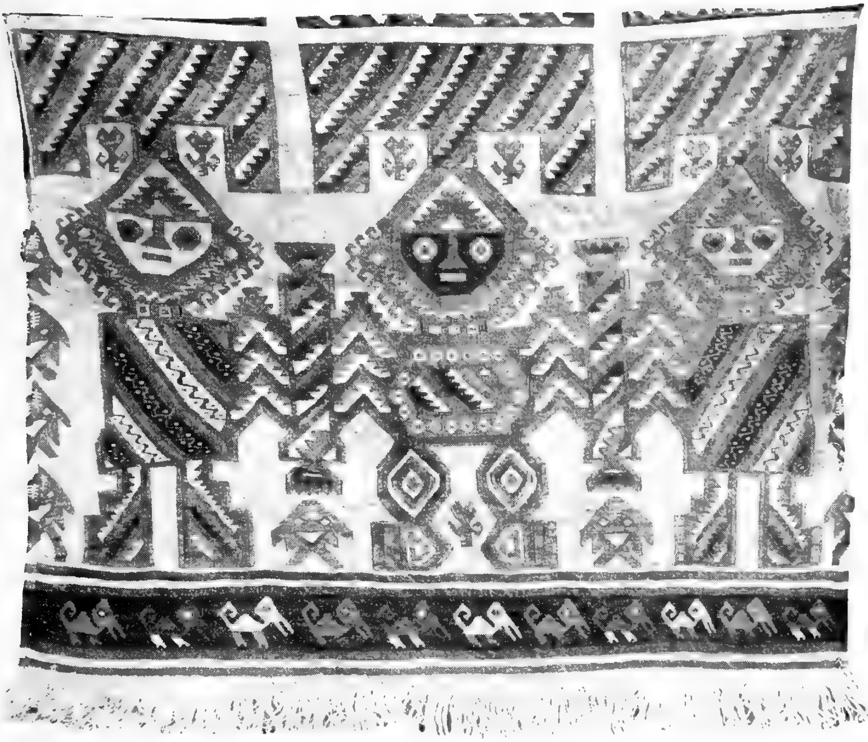
A SECTION OF EMBROIDERED MANTLE, PARACAS PERIOD, PERU. Possibly 2000 years old, Paracas embroideries are famous for the intricate use of rich colors in strange designs and figures. Trophy heads, frequently portrayed, are seen here pendant on the staffs held over the shoulder.



A PERUVIAN WOMAN'S WORK BASKET. Containing carded fiber, spindles, bobbins, and other equipment for spinning and weaving.

PARACAS EMBROIDERY. A fine example of highly conventionalized treatment of a cat figure.





A PERUVIAN TAPESTRY. An excellent tapestry from Pachacamac, Peru, with slits left open between color areas as part of the design.

In special exhibits are grouped such things as musical instruments, whistling water jars, examples of intentionally deformed human heads and trephined skulls showing the successful practice of a delicate surgical operation by the ancient Peruvians.

Much of our knowledge of their daily life we owe to a fortunate combination of climatic conditions and tribal customs. Along the coast of Peru, where the extreme dryness of the climate has preserved perishable materials for centuries, are more extensive burial places than anywhere else in America. Countless thousands of bodies were buried with such things as had been most useful and prized during life or were considered to be most serviceable in a future life. Examples of these mummy bundles are displayed, and it was from such as these that many objects in the hall were obtained.

The mummy in the case at the west side of the room was found in a copper mine at Chuquicamata, Chile. The body is that of an Indian miner who was killed by the falling of rocks and earth while he was getting out the copper ore (atacamite) used by the Indians in making implements and ornaments in prehistoric times. The tissues of the body

MODEL OF ALACALUF HUT. Used by nomadic fishermen in southern Chile, this type of shelter is well suited to the cool, rainy environment. The floor plan of these huts is oval, about 13 by 8 feet, with a fireplace in the center between the two entrances. Sea lion skins serve as covering.

have been preserved by copper salts with which they are impregnated. The tools he was using at the time of his death are lying beside him in the case.

Much more primitive than any of the prehistoric people just mentioned were the nomadic hunters and fishermen who lived in the southern end of the continent and the neighboring islands. Their story from the time when they hunted the extinct native American horses and ground sloths, about nine to ten thousand years ago, was recovered from caves and shell mounds. The simple tools and weapons they used are arranged in time-order in a case in the rear of the hall. Near by are examples of the equipment of the various tribes still living in the same region at the present time.

In neighboring cases are exhibits for other living Indians of South America. As there are a great many distinct tribes, sometimes living in widely different geographical areas, the collection is far from complete. An example of native life in the tropical rain forest of northeastern Peru is shown in a miniature group of the Montaña Indians. They raise plantains and cassava and hunt small game, so their equipment is naturally specialized for these occupations. This latter exhibit is temporarily on display in the MEN OF MONTAÑA HALL: a temporary exhibit hall.

The Pacific

Two halls are devoted to the peoples of the Pacific Islands and of Australia. The first, SOUTH PACIFIC HALL, contains collections from Polynesia, Micronesia, Melanesia, New Guinea and Australia. Polynesia, as represented by the Maori of New Zealand, extends into the second hall, which is principally devoted to exhibits from the Philippine Islands, small special exhibits from New Guinea, and special collections from Java, Sumatra and Borneo.

The most conspicuous objects in these halls are the Easter Island statue, the models of Tahitian and Philippine life, including a Philippine tree house, the collection of tattooed heads from New Zealand, and the collection of masks from New Ireland.

EASTER ISLAND STATUE. Easter Island, in the South Pacific, is famous for the immense stone statues found there, from one of which a Museum expedition made the cast here illustrated.

On entering the South Pacific Hall, beyond the Hall of Minerals, the visitor sees a huge stone face, a cast of one of the famous Easter Island statues. This was brought back in 1935 by the Templeton Crocker Expedition. These statues are unique to Easter Island. They were found set on stone platforms all around the island. Their origin and exact meaning are unknown.

Directly in the center of the hall is a Tahitian priest taking part in the fire-walking ceremony, in which the participants walk over heated lava boulders. On each side is a group showing natives engaged in typical activities – grating coconut, preparing kava or plaiting pandanus.

Just behind the Easter Island statue is a fine Hawaiian feather cape, such as was formerly worn by the highest ranks of the Hawaiian society. Red and yellow honeysucker feathers, which were collected as taxes, were fastened on a netted twine foundation. The value of these garments depended on the enormous labor spent on their making.

The hall is roughly divided into two main sections. In the first half are shown the collections from Polynesia and Micronesia, while the second half is given over to New Guinea, Melanesia and Australia. However, it proved impossible to be wholly consistent and to separate Melanesian Fiji from Samoa and Tonga.

In the POLYNESIAN section, the examples of decorated native bark cloth (tapa) are especially noteworthy, and a number of canoe models remind us that these people are daring seafarers. A series of ceremonial adzes from the Cook Islands in the farther quarter of the hall shows aboriginal carving at its best.

In the section on the right, the elaborately carved sacred masks, about 14 feet back of the Tahitian fire-walker, illustrate the type of carving characteristic of the Melanesians of New Ireland as do the two delicately carved poles against the west wall.

Another beautiful and distinctive style is found in the carvings of

POLYNESIAN BARK CLOTH OR TAPA. This cloth was made from the inner bark of the paper-mulberry tree which is steeped in water, thinned out with a shell scraper, and pounded on a board with a mallet. Designs may be painted on the cloth free-hand, but more frequently they are printed from wooden stamps.

A SECTION OF A MANUS (ADMIRALTY ISLANDS) VILLAGE, reconstructed with scientific accuracy in every detail; one of many miniature models in the American Museum showing native home life and activities.

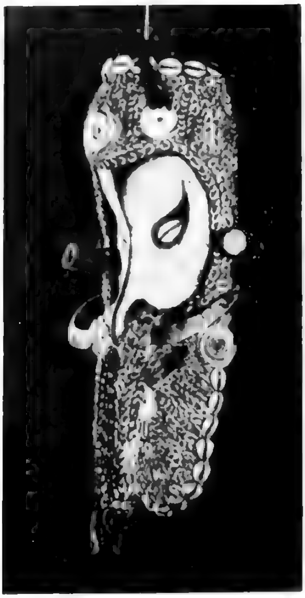
the Maori of New Zealand, where a spiral motif is dominant. The series of dried and tattooed heads forms one of the most remarkable exhibits in the Museum.

Near the boundary between the two main sections are the AUSTRALIAN cases with numerous boomerangs and very crude stone tools, which should be compared with those in the archaeological hall. The farther corner contains a collection from the Admiralty Islands, including a model of a village of the Manus tribe, a lagoon-dwelling, fishing people who build their houses on piles far from land. In the right corner of the hall are shields, clubs, carvings and household utensils from New Guinea.

The islands of the Pacific Ocean may be divided into two types: the high islands which represent remnants of sunken land masses or else the result of volcanic action, and the second variety consisting of low coral atolls rising not much more than 20 or 25 feet above the sea. The environments that these islands provide for their inhabitants are strikingly different and have affected the kind of life they are able to lead.

The high islands are, for the most part, fertile and well covered with a variety of vegetation. The coral atolls have little or no soil and support a very thin plant life. Although both high and low islands occur in various parts of the Pacific, there are two principal areas where the coral atolls are specially concentrated: one is in Micronesia and the other in the Tuamotu chain of Eastern Polynesia.

The people who live in these various islands belong to a number of different stocks. The Polynesians occupy the easternmost islands and



MASK. TCHAMBULI,
SEPIK DISTRICT,
NEW GUINEA.

CARVED WOODEN HOOK USED IN DECORATING MEN'S HOUSES IN TCHAMBULI, NEW GUINEA.

SACRED FLUTE, MUNDUGUMOR, NEW GUINEA. These flutes, known as crocodile spirit children, are so heavily encrusted with shells that they are non-functional.

Left, CARVED HOOK, TCHAMBULI, NEW GUINEA. Right, WAR CHARM, made by the people of Pak in the Admiralty Islands. It is worn on the back, and it is believed that when a man is slow in going into battle the charm scratches his back and urges him on.

differ significantly from the dark-skinned, frizzly-haired people of Melanesia on the one hand and from the short, more Mongoloid type found in the Micronesian islands.

Culturally, these three major island groupings also show differences that suggest, to a large extent, independent histories. The Polynesians manufacture bark cloth and matting, have no pottery, drink kava, fight with clubs, and are skilled navigators. They are governed by chiefs who trace their ancestry back many generations. The Melanesians make some pottery, do grotesque carvings, use bows and arrows and spears for hunting and fishing. They have men's cults into which boys are initiated and from which women are rigidly excluded.

The Micronesians live on the chain of small islands extending south from Japan to Melanesia. They are characterized by a complex political organization, great skill as navigators, and a simple food economy based on the sea.

The peoples of the New Guinea mainland and the interior of some of the larger islands of Melanesia can be grouped together as land peoples, speaking complex or non-Melanesian languages.

The aboriginal inhabitants of Australia had one of the simplest technologies to be found in the contemporary world. A hunting and food-gathering people, their tools and weapons had to be carried with them, and almost all the elaborations of their culture were expressed in songs, dances and complicated marriage patterns which cannot be shown in Museum cases.

PHILIPPINE TREE HOUSE.

Collections from the Philippines and Malaysia

This hall is reached by turning to the right in the South Sea Island Hall.

The side aisles display Philippine Island objects. The farther section of the hall contains exhibits from other parts of Malaysia with an interesting series of marionettes from Java.

At the right of the entrance is a case containing life casts of faces, noses and hair from the different races represented in this hall, also charts of stature and head form, with distribution maps.

In the center is a model of a Filipino bamboo-walled and thatch-roofed house. At the far end, a native tree house dominates the scene, and on the left may be seen the model of a woman weaving a garment on a native loom.

The visitor should note that, like the African Negroes, the Malayan tribes represented in this hall use iron tools. The numerous iron weapons

— spears, battle-axes, and krises (daggers with serpentine blades) — are especially remarkable.

On the left side of the hall are found a number of exhibits of native krises, shields, fabrics, basketry and pottery. Pottery is not highly developed in this area, but the textile arts flourish to a remarkable degree. The industrial life of the Bagobo of Mindanao is particularly well-illustrated in the collections.

Much more primitive in their culture than the other Malaysians are the Negritos, a dark-skinned and frizzly-haired pygmy stock forming, with like groups in other parts of the world, a distinct division of the Negro race. They are everywhere hunters, using the bow and arrow, and ignorant of agriculture. Their simple tools are shown in a table case in the farther section of the hall.

The islands lying close to the coast of Asia have been subjected to several migrations and to varying cultural contacts. The present population is predominantly Malay in origin, members of the great Mongolian race. Their cultural arts include pottery, metal work and textile. The metal work is especially fine in the weapon-making of Java and among the Mohammedan inhabitants of the Philippines. Among the textiles are exhibited the batik work of Java, the tie-dyeing of the Bagobo in the Philippines, and fine textiles of Luzon.

They possess fowls and pigs, grow rice, and use the carabao, or water buffalo, as a domestic aid in farming and transportation. Their form of the widespread Pacific canoe type usually has a double outrigger. Their weapons are blow-guns, bows and arrows, spears, and knives. In parts of Melanesia, head hunting was formerly practiced and formed a striking cultural feature in this area.

Although the Malay culture has deeply influenced all the peoples of the area, influences from India and China have also been felt here; the former affecting thought and philosophy, and the latter furnishing, through commerce, cherished objects of art and use. More recently, Mohammedanism has entered the islands and has become the prevailing religion in some of them. About 300 years ago, Christianity and European culture were first introduced by the Dutch and the Spaniards.

Asiatic Ethnology

At the entrance to this hall to the right is a section given to a brief exposition of the prehistory and early historic periods of Japan. The exhibits on the left side illustrate in the main the life of the Chinese at the turn of the century when the bulk of the collections was made, so that many of the objects shown here no longer have a function in Chinese life. Bamboo, porcelain, basketry, inlaid work, cloisonne enamel, lacquer, farming implements, carvings in wood, ivory and stone, costumes, and embroidery are shown to advantage. Several technological processes are shown in detail, such as cloisonne and the history of printing.

CHINESE BRONZES. A set of three bronze ornaments inlaid with silver from the Sung Dynasty, 960-1279 A.D. To the right is a bronze libation cup, probably used in religious ceremonies, from the Shang Dynasty, 1766-1122 B.C.

CHINESE BRONZE BOWL. This large bronze bowl has the original scroll design characteristic of the Chou Dynasty. Attributed to the Sung or Ming Dynasty.

A PAIR OF CHINESE BRONZE HORSES. They may have represented the horses of a chariot which has been lost. Ts In Dynasty.

AN EXAMPLE OF CHINESE CLOISONNE ENAMEL FROM THE CHINESE COLLECTION OF THE MUSEUM.

A RELIGIOUS IMAGE, TIBET. The Victorious Goddess of the Ushnisha, a feminine divinity, known in Sanskrit as Ushnishavijaya and in Tibetan as gtsug-tor-rnam-par rgyal-ma.

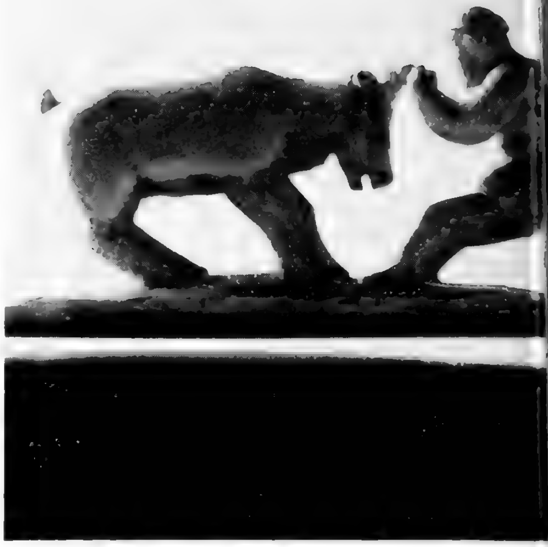
In the wall cases to the left of the entrance is a collection of ancient Chinese bronzes, and adjacent to the tower at the left is the Whitney collection of Lamaistic ritual objects from Tibet, supplemented by costumes and household utensils used in daily life by the Tibetans.

Next to these is a series of the Vedic and Puranic gods of India.

The way of life of the island Asiatic peoples – Japan, Ainu, and Korea – is shown in the west end of the hall. Of particular interest are the two models of Japanese dwellings, an example of Japanese armor and No drama masks.

Other peoples represented are some of the tribal groups such as the Meiteis and Maring of the Assam-Burma region and the Chin and Kachin of the Upper Chindwin River, Burma.

The right side of the hall is occupied by the Chukchi, Koryak, Tungus, Yakut, Lamut, Yukaghir and Gold, all of whom live in Northeastern Siberia including the Kamchatka Peninsula. The Koryak, for example, are related in language to the Chukchi and Kamchadal, with whom they share many cultural attributes. Like the Chukchi, they are divided into a Reindeer and a Maritime branch, but differ from their neighbors in the almost exactly equal size of these divisions. The Reindeer Koryak live mainly on the flesh of their herds. The Maritime group depend largely on fishing, while the hunting of sea mammals is also important but relatively less so than among the Maritime Chuchi. The Reindeer people live in movable tents. The stationary, partly underground house of the Maritime division is illustrated by a model. Both divisions of the Koryak wear clothing made of reindeer skins.



IVORY CARVING OF A BOY AND REINDEER FROM THE YAKUT, EASTERN SIBERIA.

KORYAK MAN IN ARMOR.

Before contact with other peoples, the Koryak had no metal and made all their implements by chipping stone. Several settlements were noted for their iron technique, which may antedate the coming of the Russians, since the Tungus and Yakut were both familiar with the blacksmith's art.

The dressing of skins and the weaving of baskets by the coiled and twined methods are important industries. Remains brought to light by excavations of old dwellings show that the ancient Koryak knew how to manufacture pottery. The Koryak have attained a high degree of perfection as carvers in wood, antler and ivory, and in the skillful handling of furs in the manufacture of their cloth.

Drummond Collection of Jade

The famous DRUMMOND COLLECTION of carved Chinese jade, amber, Japanese ivory, and sword-guards is in the Southwest Tower on the fourth floor, opening out of the South Sea Island Hall. This magnificent collection gathered by the late Dr. I. Wyman Drummond and presented to the Museum in his memory, is installed as a unit, largely according to Dr. Drummond's original arrangement.

It is really a group of collections, each one of the greatest importance and beauty. The JADE COLLECTION alone is a rich and well balanced series, representative of all periods and covering a cultural range of more than thirty centuries. The left half of the room is devoted to jade arranged by periods, while the right half is given over to AMBER, IVORY, LACQUER, and BRONZE SWORD-GUARDS. The oriental amber displayed is the finest of its kind in the world.

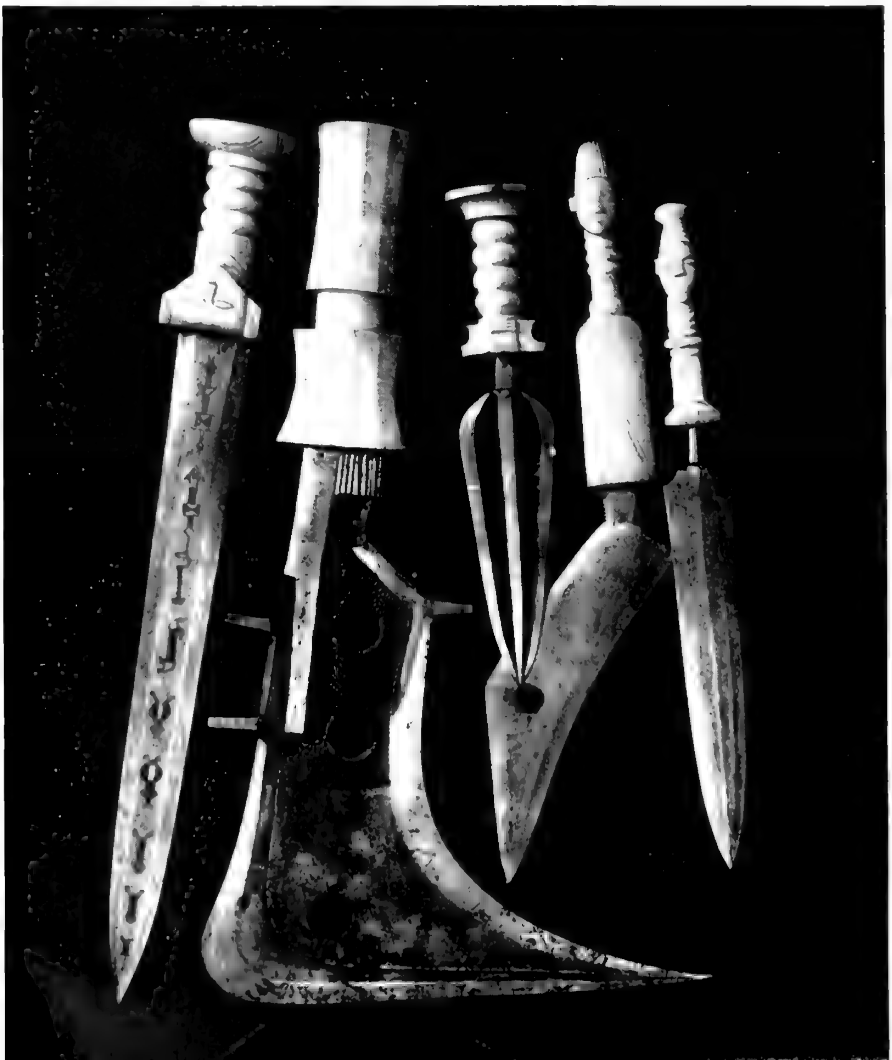
A unique composite piece of white jade, occupying the center of the room, was a birthday gift to the Emperor Kien Lung from the officials of his court. This assemblage of jade carvings consists of thirteen pieces fashioned from purest white jade and fitted together. Surrounding the central piece are twelve segments fitted together, each of which is carved with a representation of one of the twelve terrestrial branches corresponding to the signs of the zodiac.

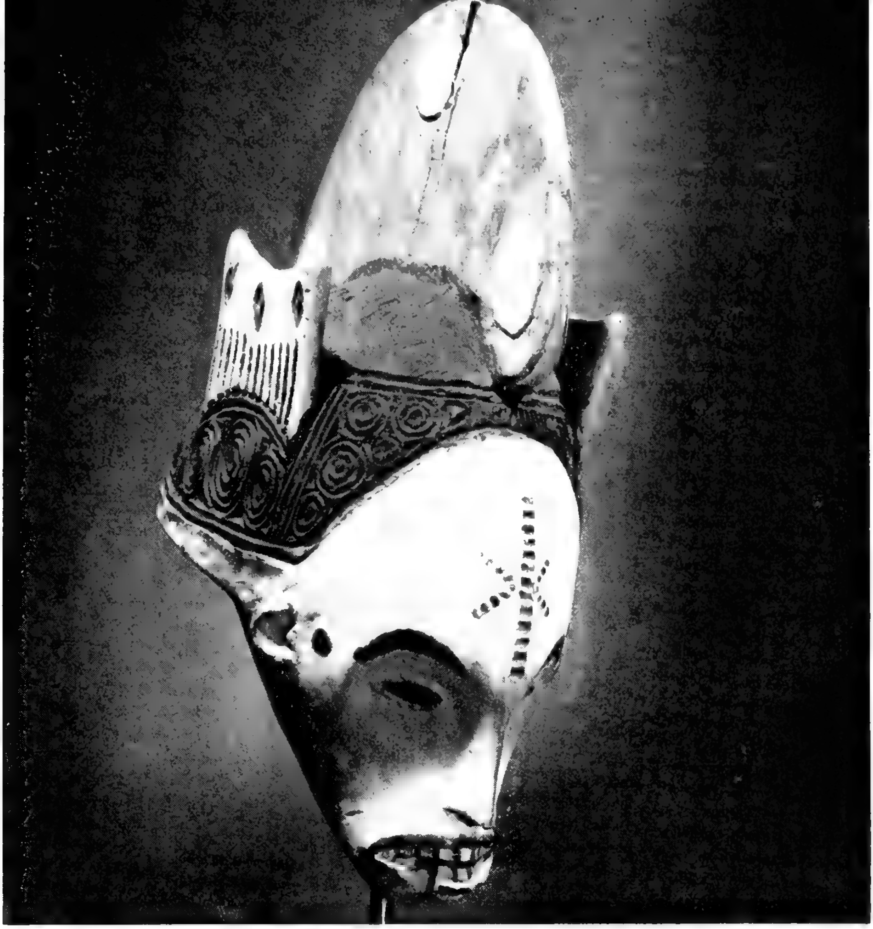
A very fine piece of white jade of the Kien Lung period of renaissance in glyptic art is in the form of a "Scepter of Good Luck" (Joo-i scepter). On the long handle of this piece are carved in high relief the figures of the Eight Immortals, the half-mythical, half-historical personages so often represented in Taoist art. Each of these carries some characteristic object, such as the flute of Han Hsiang-tzu, whose marvelous tone caused flowers to grow and blossom instantly.

AN EMPEROR'S BIRTHDAY GIFT. An assemblage of elaborate carvings fashioned from purest white jade and fitted together.

PICTOGRAPHS from Mangbettu carved camwood and ivory boxes.

IVORY HANDLED IRON WEAPONS OF THE MANGBETTU. The great sickle-shaped knives were worn over the shoulder by the king and other prominent men when they were sitting in council, partly as proof of the wearer's readiness to strike. At other times the knives were pushed under the belt.





MASK. IBO, NIGERIA.

African Ethnology

The order in this hall is roughly geographical. Thus, as the visitor proceeds through the hall, he meets the tribes that would be found in passing from south to north in Africa. The West African peoples are represented along the left hand wall, the East African along the right hand wall, and the tribes of the Congo around the central rectangle.

Nothing is more characteristic of the Negro culture than the art of smelting iron and making iron tools. The process used by the African blacksmith is shown in a group on the left at the entrance and the finished products, such as knives, axes and spears, are amply displayed throughout the hall. The knowledge of the iron technique distinguished the Negro culturally from the American Indian, the Oceanian and the Australian.

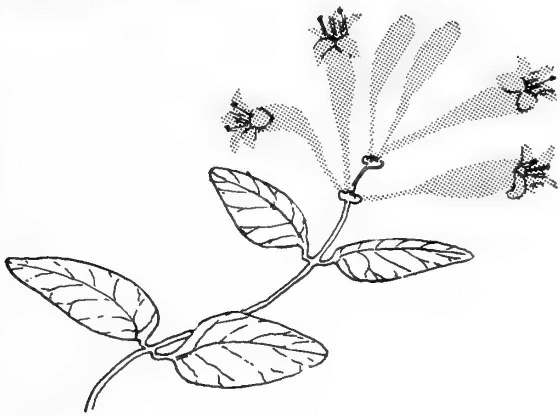
A pictorial map indicates the various culture areas distinguished on the continent. Clothing is either of skin, bark cloth, or loom-woven plant fiber. The manufacture of a skin cloak is illustrated by one of the figures

in the group to the left of the entrance. Bark cloths from Uganda are shown in the farthest right-hand section of the hall, while looms and the completed garments are on view in the large central rectangle given over to Congo ethnology. The most beautiful of the last-mentioned products are the "pile cloths" of the Bakuba, woven by the men and supplied with decorative patterns by the women. Very fine wooden goblets, fetish figures, masks, and especially a series of ivories from the Congo, bear witness to the high artistic sense and craftsmanship of the African natives. The importance of musical accompaniment to their ritualistic dances is demonstrated by the great variety of musical instruments.

A unique art is illustrated in the Benin case in the farther section of the hall where the visitor will see bronze and brass castings made by a process similar to that used in Europe in the Renaissance period.

The religious beliefs of the natives are shown by numerous fetishes and charms, believed to give security in battle or to avert evils. Ceremonial masks are shown, which were worn in native rituals.

CONSERVATION AND GENERAL ECOLOGY



Wherever you go on land or water you will find living things. Usually both plants and animals will be present, although the kinds will vary greatly from place to place. These natural assemblages of plants and animals that live together in the same area are spoken of as wildlife communities. Ecology is the branch of natural history that concerns itself with these wildlife communities. It seeks an understanding of (1) why they vary from region to region, (2) how they function, (3) how each species present has become specifically adapted to life in such a community, (4) what the relation of each is to the other members of the community, and (5) what contribution each makes to the welfare of the whole.

In any region local differences in slope, elevation and drainage, the character of the underlying rock or glacial deposit, and the varying impact of natural or man-induced "disasters", produce a series of different wildlife communities. However, the basic structure and organization of a wildlife community is everywhere the same. It must have, first of all, plants capable of locking up and storing some of the sun energy that falls on the area it occupies.

To perform this task plants borrow from their environment carbon dioxide and water molecules, and, using these as raw materials, they

build sugar molecules in which some of the sun energy is locked up. This energy is then used by plants to build other more complex plant substances in which are incorporated additional elements such as nitrogen, phosphorous, sulphur, calcium and potassium. In time these become the tissue of some part of the plant's structure or of its seeds.

These plant substances are the base which supports a community's animal life, as well as its parasitic and saprophytic plants. Saprophytic plants are those that feed on rotting wood and other dead organic matter. Buds, leaves, fruits, sap and the many other forms into which these plant materials are finally converted, serve as food for a host of different plant-eating – herbivorous – animals. As most herbivorous animals are rather specialized in their diet, the average community has places – or, as an ecologist would say, niches – for many such species. Through the process of digestion the various plant materials are absorbed into the bodies of animals, where they provide the organic building blocks from which animals fashion the tissues of their own bodies. Equally important is the energy that these plant substances make available to animals. All an animal has to do is to oxidize them, and the locked up sun energy is released. It is this energy that makes an active life possible for an animal and keeps it warm if it is warm-blooded.

Few natural communities stop here. They have, in addition, a lesser number of flesh-eating – carnivorous – animals that differ from herbivores in that they obtain their food supply of plant-originated organic materials second-hand; in other words, rearranged into meat or fat. In fact, those carnivores that prey largely on other carnivores may be said to obtain their supply of sun energy and organic building blocks third-hand. In many of the more complex wildlife communities the steps are carried still further, and food chains with five, six or more links are not uncommon. However, it takes a lot of plant material to support one large animal at the end of a long food chain and a community never has many individuals of such a species.

Man lives either by exploiting natural plant-animal communities for products he can use or by destroying them and substituting artificial communities that are more productive in terms of his specialized needs. The latter we call farming, and we either directly harvest the plants for human use or utilize tame herbivores like cows and chickens to harvest them and turn them into products we can use. Farmers regard most plant-eating wild animals as potential competitors. To keep their numbers down to a minimum, wise farmers encourage predators like the insect-eating songbirds, moles and skunks, and the rodent-eating weasels, hawks and owls. If conflicts arise because chickens and other domestic animals are also attacked, it is often wiser to give such livestock better protection than to kill the offending carnivore and lose its help in holding down crop-eating wild animals.

Conservation is often called applied ecology, because we must first understand how plant-animal communities live and function if we are

to manage them wisely. It is therefore one of the chief tasks of the Museum's Department of Conservation and General Ecology to make better known the natural laws to which man must conform if he wishes to exploit land or a natural community without impairing its future productivity.

As students of natural history we are also interested in the preservation of samples of every wild plant-animal community that is native to this continent. Only if we are successful in this, will coming generations of naturalists have an opportunity to study and enjoy all the forms of wildlife now native to North America.

There are some plants and animals that cannot tolerate any disturbance by man of the community of which they are a part, so we seek to have communities set aside as nature reserves, free from human interference or management of any sort. Such areas have a very special value to students of natural history, as a wild plant or animal is only truly and wholly understandable in terms of its role as a functional unit or cog in the community of which it is an integral part. Its evolution through the centuries to its present form, possessed of certain specific habits and other attributes, took place in the setting provided by such a community. Here it is continually subjected to the normal impact of competition, predation, and the many other forces that operate within a community on every one of its members — influences that are essential to the continuing health of a species.

FELIX M. WARBURG MEMORIAL HALL

Here is dissected for you a typical rural area near New York City. We show you something of both its geological and glacial history and its more recent history under the impact of man. We show you its wildlife communities and some of the artificial ones with which man replaces them. Here you can see the history of man's attempt to exploit more fully the land and how nature re-establishes wildlife communities when man, because of his failure to maintain soil fertility, abandons further attempts at cultivation. Here are samples of the area's soils, its bodies of water and woodland, and the cycles of life and decay within the communities that occupy them. You can see how differences in rocks and soils tend to produce different wildlife communities. In short, we help you to explore and understand the ecology of a typical landscape.

AN OCTOBER AFTERNOON NEAR STISSING MOUNTAIN. Stissing Mountain, a hard mass of gneiss, is the most commanding topographical feature in the Pine Plains' landscape. Here we see it in the glowing colors that are one of the outstanding characteristics of the deciduous — leaf-shedding — forest of Northeastern United States. Here, too, are a few of the animals that form an integral part of the community — the blue jay, red fox and dragon fly.

BIRD'S-EYE VIEW OF STISSING MOUNTAIN AND VILLAGE OF PINE PLAINS. This relief map shows you the Pine Plains area as it appears today. Its mosaic of fields and forests is typical of most agricultural communities in the glaciated Northeast. Local variations in such factors as slope, soil texture and depth, nature of underlying rock and proximity of water table, underlie such a pattern and are the subject matter of the Hall.

GEOLOGICAL HISTORY AND STRUCTURE. Pine Plains' present mountains and valleys are the end product of many millions of years of weathering, rock formation and re-weathering, and earth movements that have folded and fractured, submerged and elevated. Here are displayed the various rocks that are now exposed at the surface and something of the forms of life that lived here when these rocks were being formed.

GLACIATION. Recently — geologically speaking — a great mass of ice flowed down from the north over this area. As it moved, it scoured away the soils and smoothed the rocky ridges. Some rock fragments were carried as great boulders; others were ground to claylike fineness. Then, some 10,000 years ago, the ice melted, leaving behind a rolling landscape of hills and marshes, ponds and lakes. Because of the glacier we have pockets of clay soil in one place, stony ones in another, and little or none on the exposed ridges.

THE WATER CYCLE. The course that rain water takes after it falls is indicated in a cross-section model of a typical rural landscape. The relation of wells, springs and flowing streams to the underground zone of saturation is indicated. Its upper level — the water table — is seen to vary with both topography and the nature of the underlying sub-strata. The sloping land on the right has been subjected to water erosion due to improper farming and will no longer yield a living for the owner.

STISSING MOUNTAIN SCENE. A landscape is a mosaic of distinctive plant-animal community units.

LANDSCAPE CROSS-SECTION. Water running downhill creates problems above ground, but is an asset below.

SOILS AND SOIL CONSERVATION. Weathered rock minerals, glacial debris and water-laid beds of sand and clay provided the raw materials for the area's soils. As these leached and plant remains became mixed with their surface layers, soil was formed. Because of their diverse origins, sandy and clayey soils, or that ideal intermediary, loam soil, all occur within relatively small areas at Pine Plains.

LIFE IN THE SOIL. Beneath our feet lies a subterranean world that teems with life. Here many insects spend part of their lives. Earthworms and hundreds of smaller animals feed on plant and animal remains, converting them into humus. Moles literally swim through the soil with the help of their powerful feet, leaving tunnels that provide runways and homes for chipmunks, mice, toads and insects.

ROOTS IN THE SOILS. The parts of a plant that occupy the soil are no less important than those that reach upward into the air. Here you see an enlarged feeding root and its absorbing root hairs. A magnified soil section shows such a hair creeping through the air and soil solution that occupies the spaces between the soil granules.

THE RELATION OF PLANTS TO GEOLOGY AND SOIL. In glaciated areas like Pine Plains much of the underlying rock is covered by deposits of rock debris that may have been carried many miles by the glacier. Soils derived from such material show no correlation with the underlying rock. On the higher areas such soil as may once have covered the rocks was scraped away. Now, with the passing of the glacier, weathering is slowly creating raw materials that pioneering plants are turning into soil. Immature soils of this sort vary greatly, as they are strongly influenced by the rock from which they have been derived.

BELOW GROUND VIEW IN WINTER. The hibernating chipmunk sleeps out the winter, but the deer mouse must forage nightly for food.

Usually, only a few plants are adapted for life in a given soil of this sort and they serve as indicators of its presence. Here are samples of four such soils derived from four of the area's rock formations, together with a few of their plants. We also see two lowland areas where an excess of lime has created what are for this region most unusual environments.

ROTATION OF FARM CROPS IN DUTCHESS COUNTY, N. Y. Here are dioramas showing the appearance of the local crop-land in early June, mid-July and early October. Here, also, are samples of some of the commoner cultivated grasses – wheat, oats, rye, barley and timothy – and various stages in the development of bean and pumpkin plants. By changing from year to year the type of crop that is grown, the humus content and fertility of the soil can be better maintained.

LIME LOVING PLANTS. Weathering limestone counteracts organic acids and produces the neutral soil needed by these orchids and other plants.

THE APPLE ORCHARD IN DUTCHESS COUNTY, N. Y. Apples are the most important tree crop of Dutchess County. Here we see an orchard in bloom, during the spraying of trees, and finally at harvest time. Enlarged models show the steps in the fertilization of the blossoms by bees and in the life history of the Codling Moth that causes so many apples to be "wormy." Spraying to kill insect pests means the destruction of both beneficial and harmful forms. After spraying, honey bees are often placed in orchards to compensate for the loss of pollinating insects.

FERTILIZERS IN THE SOIL. Here two sods demonstrate the difference that the application of needed fertilizers can make in the growth of pasture grasses. A model shows the appearance of the root of a legume (member of the Pea Family) with its nodules containing bacteria that

convert atmospheric nitrogen into a form usable by plants. As other nutrient elements, if lacking, must come from fertilizers, some of their common sources are indicated.

CYCLE OF NUTRITION AND DECAY. This exhibit deals with photosynthesis and the circulation within a community of the inorganic nutrient elements that plants use as raw material in the manufacture of organic substances. It points out how first plants and then animals use these substances both as a source of energy and as building blocks for the construction of their own bodies. Ultimately, all organic materials are oxidized and their stored energy released. With this last step all the locked-up elements are freed and again available to plants to start the process over. Only the stored sun energy is lost, and as long as the sun shines a fresh supply of this is always at hand.

LIFE IN THE WATER. The cycling of nutrients in an aquatic environment follows the same pattern as on land. Here the most important plants are minute, often one-celled algae that cloud sunlit fertile waters with a green haze. Feeding on these plants are myriads of small animals like the abundant water flea. These in turn are consumed by small fish that soon become the food of larger ones. As on land, scavengers and bacteria finish the cycle and restore to the water the nutrient elements that were originally used by the algae.

CYCLE ON NUTRITION AND DECAY. Only sun-energy is used up in nature's cycles of life and death.

POND PREDATORS. A series of progressively larger predators forms an important part of the cycle of life in any environment.

FROM FIELD TO LAKE. In a glacial area like Pine Plains the surface of the ground is very uneven. In many instances the top of the water table may be above the surface, creating a pond or stream, or close to the surface, creating a marsh. The roots of land plants cannot function in saturated soil and are therefore confined to the zone above the water table. Here we observe what a difference a few inches in elevation or in soil texture can make in the character of the plant-animal community that occupies the site. From left to right in this group we see:

1. A field with enough soil depth to raise corn, also a few crows that are more likely to be seeking grubs than pulling corn.

2. A running trout-brook fed by cool underground water that slowly seeps horizontally through the soil from points where the water table is higher than the level of the brook.

3. A sedge meadow, bordered by shrubs, where dead plant material, protected from oxidation by the high water table, is accumulating to form a pocket of organic, muck soil. Here we see the shrub-dwelling yellow-throat.

4. A red maple swamp growing on a muck pocket, with a ground cover of skunk cabbage and cinnamon fern. The box turtle and red eft are common inhabitants of moist woodlands.

5. A ridge of coarse glacial material only deep enough for trees like paper birch, chestnut oak and hemlock, that are adapted to a thin soil layer.

6. A pond border where the ground is close enough to the surface for such emergent aquatic vegetation as cattails, and where muskrats, Virginia rails and bullfrogs are at home.

7. A shallow pond where catfish, yellow perch and pickerel thrive in the warm water and a painted turtle suns itself among yellow water lilies.

SEASONS IN THE LAKE. Four lake cross-sections indicate the temperature variations that occur within a body of water throughout the year. Water reaches its maximum density at 39° Fahrenheit. The effect this has on the circulation and oxygen content at various levels is indicated.

SEASONS IN THE WOODS. The progression of the seasons brings much more marked changes in a deciduous – leaf-shedding – than an evergreen woodland. In the spring the sunshine reaches the forest floor in almost its full strength. Many of the small plants of the forest bloom, produce a year's store of food, and ripen their seed in the short interval before the trees put on their leaves. Others, like the goldenrod and aster, grow slowly all summer on the small amount of light that filters through the canopy, and in the fall, as the leaves begin to drop, they burst into sudden activity, blooming and forming seed in the matter of a few weeks. The activities of woodland animals also change with the seasons and many of the birds are only summer members of the community.

THE CHANGING FORESTS. For each of the earth's climates there is often one community that is more stable than any other. It is called the climax community. At Pine Plains it is a deciduous forest community with more or less hemlock mixed through it. Local sites occupied at present by other communities tend to evolve towards this climax community if not disturbed. In the foreground of the exhibit we see an abandoned field in an early stage of a progression back to forest. On different sites the early stages of the succession of communities that leads ultimately to forest may vary greatly, as indicated in the small dioramas. The complete suppression of forest reproduction that results when cattle are allowed in a woodland is also shown.

MAN AND THE LAND. Here are five panels showing important phases in the land-use history of the Pine Plains area: (1) The extensive forest broken only here and there by small Algonquin Indian settlements, Indians who practiced a primitive agriculture in order to supplement the wildlife they harvested from the forest. (2) In the 1700's the white settlers began to move in and clear away the forest to make fields. (3) The soil, rich with the humus that had accumulated for centuries

under the forest, grew bountiful crops for over a century. (4) By the 1880's the failure to replace humus and the nutrient elements shipped away in the crops, led to soil erosion, exhaustion of fertility, and abandonment. (5) Today we see the area in a new cycle of argiculture based on the extensive use of soil-building, erosion-preventing grasses and other forage crops supplied with the nutrient elements they need by the proper use of commercial fertilizers. The common agricultural tools of each period are shown in miniature.

RECORDS OF TIME. Here you see some of the methods that enable us to read the history of a landscape. Small ponds left by the melting of ice blocks gradually fill with plant remains in which are trapped wind-blown pollens. Protected from oxidation by water, this material gradually turns into layer after layer of peat. Spruce pollen in a peat layer bespeaks a cool, wet climate, while oak pollen indicates a warm, dry climatic interval.

Glacial waters are loaded with clay-forming rock flour. In quiet lakes this settles to the bottom. Seasonal variations in the character of the sediment enables us to distinguish each year's deposit. Thus, we can determine how long it took the glacial ice to disappear completely from the area.

NORTH AMERICAN FORESTS

A forest is far more than just an assemblage of trees. In this Hall we deal with forests as complete plant-animal communities. Because of local variations in such factors as slope, soil and moisture, a forest landscape will generally contain examples of more than one type of forest community. Each community will be dominated by tree species that have become especially adapted for life on a particular site. These dominant trees set the stage, as it were, for a host of smaller associated plants and a vast complex of animals that are supported by the over-all plant community.

Some types of forest communities are sharply separated from neighboring ones. More often, one type will merge into another over a broad transition area. In such transition zones the abundance or frequency of occurrence of certain trees will increase, while others decrease. Trees that may be dominant in one community will often persist in small numbers in an adjacent one.

The normal or characteristic forest of a region is the relatively stable, mature forest — capable of reproducing itself for generations on the same ground — that occupies the most favorable sites of the area, sites that provide deep, moist but well drained, fertile soil where wind and other climatic factors are normal.

The Hall of Forests will contain dioramas showing ten regional groups of forest communities. Many will portray not only the typical forest community of the most favorable sites, but one or more of the

associated types that occur on dryer, wetter or otherwise less favorable areas for tree growth. The hall will also contain displays that will acquaint you with such topics as —

1. The characteristic soil and soil life of various forest communities.

2. The wildflowers and other minor plants characteristic of different forests.

3. The forest animals and the food chains that link them to the plant community.

4. The value of forests to man and how forests should be treated.

5. How forests reproduce themselves.

At the entrance of the Hall you see a large 16 foot cross-section of a 1310-year-old Big Tree from the King's River sequoia grove on the west flank of the Sierra Mountains of California; also a smaller cross-section of a redwood log from the Coast Range of California.

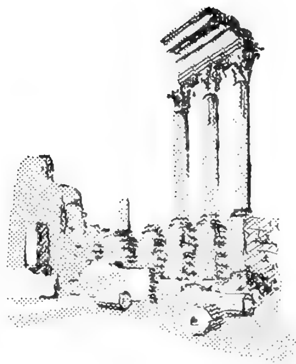
Three of the dioramas are now on display:

The SUGAR MAPLE GROUP shows a scene in early spring on a farm in Black Dome Valley in the Catskill Mountains of New York. In the foreground is a sugar house where sap from the tapped maples is being boiled down to syrup. In the background you see the north flank of Blackhead Mountain covered with a Northern Hardwood Forest in which sugar maple, beech, yellow birch and hemlock are the dominant trees. In the valley the cutting of hemlock for tan bark and of beech and birch for fuel has converted this forest into an almost pure stand of sugar maple.

The WHITE PINE–HEMLOCK–NORTHERN HARDWOODS FOREST GROUP is located near Lake Sunapee, N. H. Here we see a slope where lumbering, fire or a storm destroyed the forest 100 or so years ago, leaving the site open and sunny enough for seedlings of white pine and the very shade-intolerant red pine to thrive. Now we see these pines maturing and the shade-tolerant hardwoods — beech, sugar maple, yellow birch — and hemlock coming in to re-establish the stable regional forest type.

The SOUTHERN HARDWOODS FOREST GROUP is located on the edge of a cove-like bench at about 3500 feet elevation on the Tennessee side of the Great Smoky Mountains National Park in the Southern Appalachians. In the group we see a sweet buckeye, a tulip tree, a white basswood and a silver bell tree. The time is late April, and dogwood, Frazier's magnolia and silver bell are in bloom and the ground is carpeted with wildflowers. This area appears to have been continuously occupied by a forest community for the past sixty million years. It is one of the world's richest forests in species, as some 130 trees occur within the park and some two dozen now reach their maximum size here.

POPULAR VERSUS SCIENTIFIC WORDS



Every task of man has its own special words. Doctors, sailors, lawyers, shoemakers, scientists, cooks and cattlemen — all have their own word lists that they use in their work. Our trouble is that we cannot be familiar with all of these occupations and their special words.

Living languages grow and change in meaning with daily use. For example, take two English words, PREVENT and LET. PREVENT used to mean KNOW IN ADVANCE. "He prevented her every wish" did not mean that she didn't get what she wanted. It meant that he could tell beforehand what she wanted. Today, PREVENT means STOP SOMETHING BEFORE IT HAPPENS.

LET used to mean STOP. In Shakespeare's time a man might say, "Let me not!" meaning "Stop me not!" But today, LET means PERMIT or ALLOW.

Common names also change with locality. Every species of animal may have scores, if not hundreds, of local names. Even the same name may not mean the same thing in different regions that speak the same language. The WHITING of England is not found in America, but the HAKE of England is the WHITING of New England, while the HAKE of Delaware Bay is a totally different fish that has nothing to do with the other two. Again, the English LING and the LING of New Jersey are different fishes.

It is plain, then, that scientists must have an international language. The solution has been to make up a word list from one or two "dead" languages that will not grow and change as time goes by. Sometimes words from other languages may be employed. Sanskrit and Hebrew would have served, but early scientists knew Greek and Latin better.

To avoid confusion, scientific names are given to animals and plants. All scientists will know these names. Our domestic dog is "dog" in English, "hund" in German, "hond" in Dutch, "chien" in French, "perro" in Spanish and "cão" in Portuguese. But all scientists — American, English, German, Dutch, French, Spanish or Portuguese — will know that CANIS FAMILIARIS is a dog in any dialect.

The Museum visitor may be surprised to find, after reading a label, that after each common name of an animal there are two words in a foreign language — usually Latin and Greek in combination. For instance, after Robin, you will find TURDUS MIGRATORIUS; after Herring, CLUPEA HARENGUS. Every known animal has been given scientific names whether it has a common name or not.

But why TWO scientific names? The two names have two functions. The Black Duck is ANAS RUBRIPES. ANAS is the generic name — it indicates relationship. Every surface-feeding duck is ANAS, as the Mallard, ANAS PLATYRHYNCOS; the Pintail, ANAS ACUTA; the Teal, ANAS CRECCA. The second name, beginning always with a small letter to set it off, is unique. It specifies the particular species. It is the specific name.

To apply the same system to human names, let's take John Smith. The scientist reverses his name thus — SMITH JOHN. SMITH is his generic or relationship name. All members of his family will be named SMITH. But when we add JOHN to his relationship name we now have a specific name, a unique name. SMITH JOHN cannot be confused with SMITH PETER, SMITH BILL or SMITH CHARLES.

In addition to using Latin and Greek names, scientists also use short-cut descriptive words. It is harder to write simple language than it is to write scientific language. It also takes more words and more space. Scientists compress their words to save time and space.

Let us take PROGNATHOUS as an example. We may say that one type of primitive man was prognathous. PROGNATHOUS is a descriptive word made up of Latin and Greek words. PRO- is a prefix meaning BEFORE or FORWARD. GNATHOS is a Greek word meaning JAW. The suffix -OUS means HAVING THE QUALITY OR PRESENCE OF SOMETHING. Therefore, PROGNATHOUS, part by part, means FORWARD-JAW-PRESENCE or, more simply, HAVING A JAW THAT STICKS OUT. PROGNATHOUS is a time-saving, short-cut word. But it takes many words to explain what it means.

We have gone around the fifty-eight halls of the Museum, reading labels. We have picked out words that we thought were least familiar to everyone. If you are reading a label and come across a word like PROGNATHOUS or PECTORAL, you can find what it means in the word list below. If you find words not on our list that you think ought to be there, please note them and pass them on to any Information Desk. Your suggestion will be given to the right people.

THE WORD LIST

ABERRANT, straying from the usual course; differing from the type of its group.

ALBINO, a person, animal, or plant lacking normal coloring matter.

ALLUVIAL, pertaining to formations deposited by rivers or floods. Alluvial plains are the flood-plains of rivers.

ARBOREAL, living or situated among trees.

ARCHAEOLOGY, the systematic study of man, his relics, remains and records.

AVIFAUNA, the birds of a given region.

BOREAL, northern.

CALCAREOUS, composed of, or containing, limestone or calcium carbonate. A clam shell is calcareous.

CARNIVORE, a meat-eater. A lion is a carnivore.

CELT, an ancient tool or weapon of stone, shaped like an axe.

CERAMIC, pertaining to pottery.

CRUSTACEAN, a lobster, crab, crawfish or shrimp is a crustacean.

CULM, stem or stalk, as of grasses.

CULTURE, the sum total of everything a group is, does, has, and believes in.

DECOCTION, the liquid produced by boiling a substance.

DETRITUS, loose fragments or particles of rock.

DIURNAL, active during the day. The eagle and the sparrow are diurnal birds.

DORSAL, pertaining to, or placed on or near, the back.

EFFIGY, a figure or image representing the whole or part of a person.

ENVIRONMENT, one's surroundings.

EPIPHYTIC, growing on the outside of another plant, mostly on trees.

EVERTED, turned backward or outward.

EVOLUTION, a succession of changes by which the forms of organisms are modified, usually from the simple to the complex.

FAUNA, all the animals living in a given area.

FLORA, all plant life growing without cultivation in a given area.

GRAMINIVORE, a grass-eater. A horse is a graminivore.

GREGARIOUS, living in flocks, herds or communities. Pigeons, cows and men are gregarious.

HERBIVORE, feeding on herbs or other vegetable matter.

HIBERNATION, passing the winter in a secluded place, in sleep or near-sleep.

HIEROGLYPHIC, picture-writing in which the figures of objects take the place of signs or letters.

INSECTIVORE, insect-eater.

INTRUSION, the forcing of masses of molten rock into or between other rocks; a mass of such rock.

INVERTEBRATE, an animal without a backbone.

LATERAL, pertaining to, or placed near, the side.

LEGUMINOUS, related to the pea family.

MELANISTIC, excessive darkness of the eyes, hair, fur, or skin, due to deposits of pigment; the opposite of albinistic.

METALLURGY, the art or science of extracting metal from its ore.

METAMORPHOSIS, a change in form, structure and function resulting in development; the changes that occur from the larva and pupa to the fully developed insect.

NOCTURNAL, active after dark. The owl is a nocturnal bird.

OCCIPITAL, pertaining to the lower back part of the head.

PARASITIC, living on or in another organism and getting nourishment from it.

PECTORAL, pertaining to the breast.

PEDICELS, stalks or supporting parts.

PHYSIOGRAPHY, physical geography, dealing in description rather than in theory or explanation.

PREDATORY, preying on other animals.

PREHENSILE, formed to grasp or coil around, as the tail of a monkey.

PRIMEVAL, belonging to the first ages; ancient.

PROBOSCIS, a long, flexible snout, as the trunk of an elephant.

PROGNATHOUS, having a jaw that sticks out.

RUMINANT, an animal that chews the cud, as deer or cows.

SAPROPHYTIC, living on dead organic matter.

SCANDENT, climbing or aiding to climb.

SEDIMENTARY, formed originally by material deposited by water or air.

SESSILE, fixed to or attached.

SHERDS, fragments of pottery.

STELA, an upright slab or tablet of stone.

STRATIGRAPHY, the order and relative position of the layers of the earth's crust.

TERRESTRIAL, pertaining to the earth.

TUNDRA, the treeless plains found in the arctic regions.

VENTRAL, pertaining to, or placed on or near, the abdomen.

VERTEBRATE, an animal with a backbone.

The Museum Shop

Make your visit to the Museum still more memorable by visiting the Museum Shop. It is one of the largest and most interesting museum shops in the world. Here, in several departments, you will find not only books, cards and souvenirs, but a wide assortment of merchandise of unusual interest that is seldom available elsewhere.

RARE AND EXOTIC GIFTS. Alert shoppers are rapidly "discovering" this unique, exciting source for gifts of special character. Original African woodcarvings, handsome reproductions of actual Museum specimens, unusual jewelry, authentically-costumed dolls of all nations, fine native crafts of all kinds — these are only a few of the distinctive items to be found there. Many articles are the only ones of their kind, many are handsome decorators' items, and all are of a character not found in ordinary shops.

SOUVENIRS. Many interesting mementos of your Museum visit will be found such as models of prehistoric and present day animals in glass, plastic and metal, novel paper weights, beautiful full-color photographs of Museum exhibits, special natural history records of bird songs, native dances, etc. For children there are toys, games, arrow heads, shark teeth, sea horses, bird pictures, and numerous other inexpensive articles intriguing to youngsters.

SHELLS, MINERALS, INSECTS. The Museum Shop offers an outstanding collection of mineral specimens, semi-precious stones, sea shells from all parts of the world, and mounted butterflies and other insects for the amateur collector. These are available singly or in ready-made collections.

PUBLICATIONS. A large library of books and pamphlets is available for your examination and purchase. These cover the field of natural history from anthropology to zoology, for both the amateur and advanced naturalist.

The Museum Shop is located on the first floor in the 77th Street Entrance Hall.

The Planetarium Shop

In the American Museum-Hayden Planetarium you will find a shop catering to the interests of both young and old in astronomy. Hourglasses, barometers, meteorites, star finders, zodiac cards, small microscopes and souvenirs of many kinds are among the objects on sale. It is also an excellent source for books on the sun, moon and stars, on weather, space travel, life on other planets, telescope making, and other subjects in the field of astronomy.

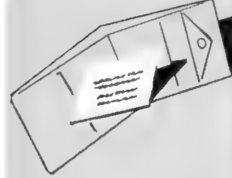
Natural History Magazine

The American Museum of Natural History publishes one of the world's most distinctive and distinguished magazines, NATURAL HISTORY. In it eminent writers, scientists and explorers present in highly readable fashion the inside story of their research, travels, investigation and discoveries. From the floor of the oceans to the outermost stars of the galaxy, from the dim beginnings of life on prehistoric shores to the probable nature of life in the world of tomorrow – such is the reader's range of vision in a publication devoted at all times to truth and to the better understanding by man of the world in which he lives.

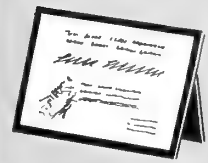
NATURAL HISTORY Magazine is filled with unusual photographs, maps and drawings. The handsome, full-color covers portraying natural history subjects of rare beauty and interest are prized by every subscriber. The subscription price of $5 a year enrolls you as an Associate Member of the Museum. You receive a Membership Card, Membership Certificate, and other desirable benefits in addition to a year's subscription to NATURAL HISTORY Magazine.

The Museum also publishes JUNIOR Natural History Magazine for young people between 8 and 14 years of age. This highly informative and entertaining publication is read avidly by both boys and girls and is valued by all adults who wish to see young people receive the right introduction to the infinite variety and inspiration of the world of nature. A year's subscription costs only $1.50.

Invitation

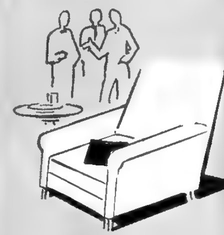


You are cordinally invited to enjoy the privileges and benefits of membership in the AMERICAN MUSEUM OF NATURAL HISTORY.



Your Museum is a powerful cultural influence in the nation, an invaluable asset to science and education, and a rewarding personal experience for all who wish to assist in its work by becoming Members. Your own participation is welcomed in any of the following Classes of Membership you choose.

MEMBERSHIP CLASSES



LIFE MEMBERSHIP — Benefits 1 through 10	$300
SUPPORTING MEMBERSHIP — Benefits 1 through 9	$100 a year
CONTRIBUTING MEMBERSHIP — Benefits 1 through 9	$ 50 a year
SUSTAINING MEMBERSHIP — Benefits 1 through 9	$ 25 a year
ANNUAL MEMBERSHIP — Benefits 1 through 7 plus 8 or 9	$ 15 a year
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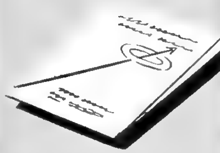
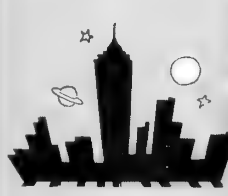
Interested people in all parts of the world find that distance is no barrier to their enjoyment of Associate Membership status and benefits in the American Museum of Natural History. Residents of the Greater New York area find the Annual and Sustaining Memberships especially rewarding.

MEMBERSHIP BENEFITS

1. Membership Card for purse or wallet.
2. Membership Certificate suitable for framing.
3. Admission to Members' Room.
4. Subscription to NATURAL HISTORY Magazine, the Museum's unique and beautiful magazine, treasured by members as one of the most distinctive and interesting publications in the nation.

5. Ten per cent reduction on books purchased from the Museum Shop.
6. President's Annual Report on request.
7. Two admissions to Hayden Planetarium.
8. Admission for the Member and a guest to the Members' Lecture Series (10 or more annually). This Series brings to the Members the nation's foremost lecturers on natural history subjects. They present full-length natural color motion pictures of extraordinary beauty and interest. The lecture evenings are pleasant, relaxed social occasions at which the Members enjoy coffee, music, comfortable lounge chairs, and the opportunity of talking with well-known authors and scientists. They bring to all present rare and memorable insights into the infinite variety of nature. (At prevailing admission prices for programs of equal merit, this Series would cost at least $30.)





9. Admission for the Member and two guests to Adventure Series (10 or more illustrated lectures annually). These Saturday morning lectures are of the same high calibre as the Members' Lecture Series. While they are presented especially for the children of Members, adults find them equally worthwhile. The Adventure Series has long been cherished by Members who value for their children a sound, constructive, stimulating introduction to the wonders of the world in which they live. (This Series, also, would cost at least $30.00 at single admission prices to lectures of similar merit elsewhere.)
10. Admission to Staff Functions arranged for higher class Members.

To obtain your Membership Card, ask any Museum attendant to direct you to the office of the Membership Secretary. Or write to Membership Secretary, American Museum of Natural History, New York 24, New York.

"The
museum
is not
four walls
surrounding a
cloistered
life;
it is the
heart of a
system
circulating
throughout
the
world."

DR ALBERT E. PARR,
Director

THE AMERICAN MUSEUM OF NATURAL HISTORY

The Murals
in the
Theodore Roosevelt Memorial Hall

AMERICAN MUSEUM OF NATURAL HISTORY

The Murals

in the

Theodore Roosevelt Memorial Hall

Written by the Artist

William Andrew Mackay

and

A. A. Canfield

of the New York State Department of Public Works

SCIENCE GUIDE 119

~~MAN AND NATURE PUBLICATION 119~~

AMERICAN MUSEUM OF NATURAL HISTORY

The Murals in the Theodor

ROOSEVELT'S EXPLORATIONS IN

THE murals in the Roosevelt Memorial Hall were painted by William Andrew Mackay and are symbolical representations of notable incidents in the career of Theodore Roosevelt. The subjects are: "Roosevelt's Exploration in Africa (opposite the entrance door of the Memorial), "The Building of the Panama Canal" (to the right as one enters the Memorial), and "The Signing of the Treaty of Portsmouth" (to the left of the entrance).

Roosevelt Memorial Hall

AFRICA, 1910

↑ [[Over the Doorway]] Against a background of a map of northern Africa is depicted the dispersal of the sons of Noah—Shem, Ham, and Japheth—after the voyage of the Ark. Ham, having shown disrespect to Noah, was cursed by his father and destined with his son and all his descendants to perpetual slavery. In the center appear Ham and his wife and his brothers Shem and Japheth at the parting of their ways. Beyond the lefthand edge of this illustration, the mural displays snow-capped Mount Kenya, with a fringe of bamboo forest on its slopes.

← [[Left center]] Theodore Roosevelt stands above a Nubian lion and lioness, flanked by his gun bearers. In this group are several birds which were added to the collections of the American Museum and the National Museum in Washington. The trophies are being studied by a Girl and Boy Scout. Theodore Roosevelt was one of the organizers of the Boy Scouts. Science is represented by a man in academic gown.

↓ [[Bottom left]] The shield combines symbolically Roosevelt's port of entry into Africa, Mombasa, indicated by the device of a red lion on a white disc, as it appears on the flag of British East Africa, and his point of departure, Alexandria, symbolized by Egyptian figures. Surrounding the shield are natives on *safari* carrying weapons and impedimenta of an expedition.

↑ [[Right]] In a tangle of gnarled trees, hemmed in by rocks, an African elephant is captured by a group of native hunters with shields and spears. At the bottom is the seal of the Smithsonian Institution of Washington, in the interests of which much of Roosevelt's African exploration was undertaken. Supporting the seal is a typical African native chief of the Kikuyu tribe, clad in a lion skin and blue headdress. At the left of this chief is Kermit Roosevelt.

← [*North Return Panel*] The zebras, blended into an early morning African landscape, show the principle of concealing coloration in nature. At the base of this return panel appear several natives of the Masai tribe, who have returned from the hunt. The woman wears a gay skirt and brass-ring necklace, and the hunters are dressed in leopard and gazelle skins, one with a monkey-skin headdress.

→ [*South Return Panel*] At the top, giraffes and ostriches blend into the landscape where they are usually found. Below upon a bent tree trunk crouches a leopard. At the base kneels a warrior with a taut bow and wearing two white ostrich plumes, evidence of his having slain two lions in single combat. Above him are the huge signal or war drums used by the natives. The entire panel is overlaid with beautiful red hibiscus and other rich African foliage.

BUILDING THE PANAMA CANAL

[*Over the Doorway*] A seated Buddha (not illustrated here) symbolizes what Columbus hoped and expected to find when he sailed west across the Atlantic Ocean—India. Seated on the right is Queen Isabella, and above her Christopher Columbus. On the left are an East Indian prince and a native.

↑[*Left center*] The three shields display (from left to right) a Mayan emblem on a blue field, a Toltec emblem (a carved stone called the cross of Tlaloc, found in Toltec ruins) on a red field, and the emblem of the Aztec nation at the time of the Spanish Conquest—an eagle holding a snake in his beak. The last-mentioned, somewhat modified, is the coat of arms of the Republic of Mexico at the present time. Between these shields, ships in battle recall the strife of early settlers with pirates.

Below these shields is emblazoned the mariner's compass, and at the right is a Mayan holding a ceremonial staff on which is perched the emblematic bird, the Quetzal. Beneath this figure are two pirates, one scanning the horizon with a telescope, the other having a hook in place of an arm lost in combat. Next are five women in ancient Spanish costume who display various products of the South American continent for which the Panama Canal provides export facilities.

The group dominated by Father Time signifies the transfer of the tugboat *Gatun*, the first craft to pass the Canal from one ocean to the other.

At the base of this panel the figures grouped about the shield of Panama represent the early founders in the development of this region. At the extreme left and right are men of the early races, the Mayan and Aztec. The figures next to the shield are a Spanish conquistador and an early pirate. The headdress of the Mayan priest is a crownlike structure adorned with feathers. The Aztec warriors carry weapons: left, a spear with flaming feather head and a huge chipped spear point; right, a sling and a bag of stones with a typical Aztec spiral design.

↑ [[Right center]] The three shields on this side of the center panel are the armorial design of Balboa, the discoverer of the Pacific Ocean, that of his Spanish sovereign, and the insigne of Republican France at the time when the Count de Lesseps initiated the enterprise of cutting a canal across the Isthmus. Below the shields are Balboa with the standard of Spain, and a pirate with the model of a pirate ship, a bag of gold, and a native monkey. At the right a Mayan of high rank holds a ceremonial staff. Beneath these appears Sir Henry Morgan, richly dressed in red, who raided the Spanish Main and eventually became Governor of Jamaica. Here also is a wrecked and rusted French excavating machine, covered with vines, remnants of which still exist beside the Canal bank. Near by is a French army officer holding plans

of the projected canal, Count de Lesseps in white, and France typified by the figure of a woman.

↓ [[Immediately below]] President Theodore Roosevelt is seen discussing plans with Chief Engineer John F. Stevens. At the left an officer holds the flag of the Engineer Corps, United States Army. An officer of the Medical Corps, United States Army, in white uniform, holds a test tube, emblem of research into the causes of pestilence. A negro sprays the ground against the mosquito pest, responsible for the yellow fever which had defeated the French in their heroic efforts to build the Canal. Laborers hold a steam drill and a crowbar. Below is a model of the Gatun Locks.

↓ [[At the bottom]] Color sergeants display the flag of the militia of the District of Columbia and the Presidential ensign with attendant elements of the Great Seal of the United States. The figures of Freedom at the left and Liberty at the right support a shield with the inscription: "Work on Panama Canal started May 4, 1904, by President Theodore Roosevelt. The land divided the world united. Completed 1914."

← [[*Left, or West, Return Panel*]] This shows the last act in the great excavation, the meeting of the two enormous excavating machines, facing each other in the final task of scooping up the remaining earth and rock of the cut. Over the map of the Canal Zone, the steam from the power shovels forms the outline of the divided continents. Below the excavators is what the artist has aptly termed "a typical American construction engineer" in a characteristic pose. This is a portrait of the New York State Superintendent of Public Works, Colonel Frederick Stuart Greene, under whose direction the Roosevelt Memorial building was constructed.

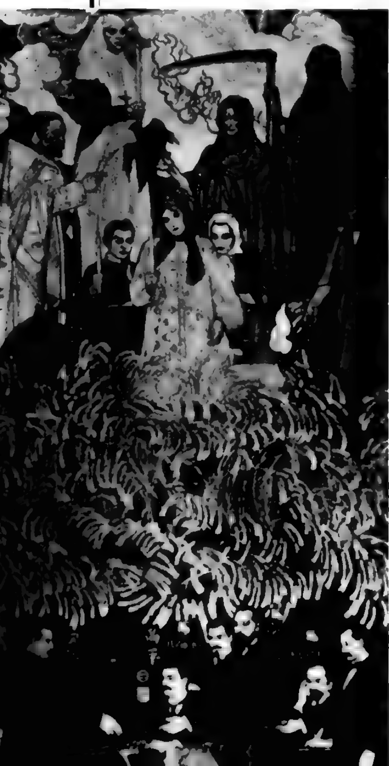
At the bottom of this panel is a typical Latin-American Canal laborer holding the coat of arms of the Canal Zone, surrounded by the armorial designs of France, Spain, Scotland, and Portugal. At the left are two natives using a loading iron, making preparations for a blast, and at the right are other typical figures engaged in the building of the Canal.

➡ ⟦*Right, or East, Return Panel*⟧ At the top is the Goddess of the River, crowned with orchids, pouring the dew from an ancient water vessel, which she has gathered from the rainbow. Down it falls to become the Unknown River, discovered and explored by Theodore Roosevelt, and named for him Rio Teodoro. The discoverer is viewing the river at its source, his native attendants with their propelling poles pushing aside the branches, disclosing the stream. The President's son, Kermit Roosevelt, is shown recording the saga.

At the bottom are members of the Parecis tribe of Indians. A warrior holds in his right hand a richly decorative shield of the map of South America with the arms of Portugal and of Brazil; in his left is an ancient musical instrument. The warriors are equipped with long bows and arrows, and one of the native women carries a basket suspended by a band from her head.

THE TREATY OF PORTSMOUTH SEPTEMBER 5, 1905

➡ The immediate theme of this section is, of course, the termination of the Russo-Japanese War through the mediation of President Roosevelt, but there is a deeper underlying idea brought out by the identity of treatment on either side of the center panel and a balance in the design, the whole brought to a focal point in the dominant figure at the top of the mural over the doorway. This is Jenghiz Khan, flanked by two of his sons, Juji and Jagatai. Jenghiz Khan, the greatest of Mongolian conquerors, typifies a common enemy engaged (to the left) in battle with early Russians, and (to the right) with medieval Japanese.



⬅ [*Left center*] Russians killed in battle lie in a wheat field, mourned by relatives and attended by a Russian priest with a deacon and a Russian nurse. Near the doorway are the figures of Death, Famine, and Plague.

At the base of this panel is the group gathered for the signing of the peace treaty. From left to right these figures are: Theodore Roosevelt, M. Takahira, C. Nabokoff, Count S. de Witte, J. Korostovetz, and Baron Komura. Count de Witte and Baron Komura are holding the olive branches of peace. The figure of Columbia with a sheathed sword draped with a band of mourning is behind Roosevelt.

➡ [[*Right center*]] Here appears the Japanese Goddess of Mercy, Kwannon, her head encircled by a halo. The group of mourners is the counterpart of the Russian group opposite except for differences in racial types and costumes. A Shinto priest gazes upon the dead Japanese soldier, and the repeated figures of Death, Famine, and Plague emphasize that both nations face the same loss and ruin which follow war.

At the base of this panel, two typical American girls represent Justice and Mercy intervening between a Japanese and a Russian soldier. At the left of the base in full ceremonial vestments is the Emperor of Japan. Behind him is a banner bearing his "Mon" or armorial device in gold on blue. The rising sun banner of Japan flies above the figure of a Japanese infantryman, while the blue cross of St. Andrew on a white field stands above the Russian fighter. At the extreme right in coronation robes and wearing the imperial crown is the Tsar, above his head the two-headed eagle on gold ground, the emblem of Imperialist Russia. The Mikado and Tsar are offering their swords in token of peace between their nations, and this is repeated in the open book of history which appears in the center.

←[[*Right, or West, Return Panel*]] Japanese legendary history. Superimposed upon the map of Japan are depicted Izanagi and Izanami, deities of Japanese tradition, standing upon the "Floating Bridge of Heaven." They thrust a spear into the ocean, and the drops of water falling from it formed the island of Onegoro or "spontaneously-congealed-island." Dwelling in the island they saw a wagtail and its mate alighting on a stone. They conceived the idea of marriage, and are held to be progenitors of "The Great Island Country." Wishing descendants to rule over the country, they became the parents of the Sun Goddess, Amaterasu.

Amaterasu appears below, where she has retreated into "The Rock Cave of Heaven" to avoid her unruly brother Susanoo. She has refused to see him before his banishment to the Land of Yomi (Hades), and the Gods

and Goddesses are disturbed at the prospect of darkness. Before the cave they have planted a Sakaki tree and upon it hung a mirror, a rosary of 500 jewels, and offerings of blue and white cloth. They finally induced the Sun Goddess to look upon a goddess more beautiful than herself—her own reflection in the mirror—and the goddess emerges from the cavern. Her consort, Tsuki, the Moon God, is shown above her.

Below is Susanoo in the act of slaying the eight-headed serpent after it had drunk a quantity of rice wine. In the background is the sacred mountain Fuji, and in the foreground, sword in hand, stands the first historic Japanese Emperor, Jimmu, descendant of Amaterasu, the Sun Goddess.

At the bottom of this panel is the armorial design of the Scottish family of Bulloch, the maternal ancestors of Theodore Roosevelt.

←[[*Left, or East, Return Panel*]] Russian legendary history. At the top is a primitive North Russian, kneeling, stringing his bow. Near him, holding spear and shield, stands the Norseman, Rurik, first historic ruler of a unified federation of Slavic tribes. The map background indicates the region of Novgorod, where Rurik first established his power.

Next below is Oleg, companion and brother-in-law of Rurik, who became Regent on Rurik's death in 879, during the minority of Igor, Rurik's son. Here Oleg is shown approaching a horse's skull. It had been foretold that he would die by reason of his horse. On its death Oleg was reassured, but going to look for the last time on its remains, a snake issued from the skull and bit him, thereby killing him. Next below appears Igor, son of Rurik, fighting with a Greek warrior, typifying his war with the Greeks in 941–944 A.D. Igor's Queen Olga held the Regency while her son

thatched roofs. The pigeons were the only tribute she had demanded, and returning them with the fire, Olga avenged the deaths of her husband and her son. The figure to the right is a chief of the Petchenegs, enemies who slew Sviatoslav, who holds a drinking cup made of Sviatoslav's skull bearing the inscription, "He who grasped at the possessions of others lost all that was his own."

In the background is a Russian church. Olga first introduced Christianity into Russia. Her grandson, Vladimir, besieged a Greek city and finally captured it after an arrow bearing a message revealing the location of the city water supply had been treacherously shot into his camp. He married the Greek princess of the city, and brought the Orthodox Greek religion to Russia as its established religion.

At the bottom of this panel are shown members of the Roosevelt family grouped around their armorial shield.

Notes about the Competition and the Artist

An open competition was held in New York City in March, 1933, for the selection of designs by an American artist for the mural paintings for the New York State Roosevelt Memorial. Twenty-five artists anonymously entered sketches. The jury consisted of Colonel Frederick Stuart Greene, the Superintendent of Public Works; William E. Haugaard, the State Commissioner of Architecture; John Russell Pope, architect of the Roosevelt Memorial; the Board of Trustees of the New York State Roosevelt Memorial, namely, Governor Herbert H. Lehman, *ex officio*; Henry Fairfield Osborn, Chairman; Peter D. Kiernan, Vice-Chairman; Mrs. Richard Derby; Charles W. Flint; Mrs. William H. Good; Chauncey J. Hamlin; Felix M. Warburg; and Abram Poole, an artist selected by the contesting artists. By unanimous vote they awarded the work to William Andrew Mackay. Colonel Greene, approving the choice and signing the sketches, contracted with Mr. Mackay for the execution of the work, which was completed and installed on the walls of the Memorial in April, 1935.

The area covered is about 5,230 square feet. The canvasses are 34 feet in height and, including the wing panels, 62 feet in length.

The late Mr. Mackay, a descendant of an old American family, was educated at City College, New York City, and studied at the Julien Academy in Paris. In his early career he assisted the great painter, Robert Reid, later being associated with Frank Millet and Elmer E. Garnsey, upon whom he looked as his master. During World War I Mr. Mackay was Chief Camoufleur of the Second District, including Newport, Cape May, and New York Harbor.

Many very fine examples of decorative work have been executed by Mr. Mackay in the Library of Congress, in the Belmont Memorial Chapel, and the famous Chinese Tea House at Newport, Rhode Island. His mural painting "The Legend of the Sargasso Sea" at Castle Gould won honorable mention at the Architectural League.


116
120
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THE KHAN
ISLAND OF
HONDO
PEKING
KALGAN
SO-PING
CHINA
JAPAN
SEA
SADO
IS.
NAGOYA

A Message from THEODORE ROOSEVELT

NATURE

There is a delight in the hardy life of the open

(African Game Trails)

There are no words that can tell the hidden spirit of the wilderness, that can reveal its mystery, its melancholy and its charm

(African Game Trails)

The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased; and not impaired in value

(The New Nationalism)

Conservation means development as much as it does protection

(The New Nationalism)

MANHOOD

A man's usefulness depends upon his living up to his ideals insofar as he can

(A Letter to Dr. Sturgis Bigelow, March 29, 1898)

It is hard to fail, but it is worse never to have tried to succeed

(The Strenous Life)

All daring and courage, all iron endurance of misfortune—make for a finer, nobler type of manhood

(The Great Adventure)

Only those are fit to live who do not fear to die; and none are fit to die who have shrunk from the joy of life and the duty of life

(Address before Naval War College, June, 1897)

YOUTH

I want to see you game, boys, I want to see you brave and manly, and I also want to see you gentle and tender

(Address at Friends School, May 24, 1907)

Be practical as well as generous in your ideals. Keep your eyes on the stars and keep your feet on the ground

(Speech at Prize Day Exercises at Groton School, May 24, 1904)

Character, in the long run, is the decisive factor in the life of an individual and of nations alike

(American Ideals)

THE STATE

Ours is a government of liberty by, through, and under the law

(Speech at Spokane, Wash., May 26, 1903)

A great democracy must be progressive or it will soon cease to be great or a democracy

(The New Nationalism)

Aggressive fighting for the right is the noblest sport the world affords

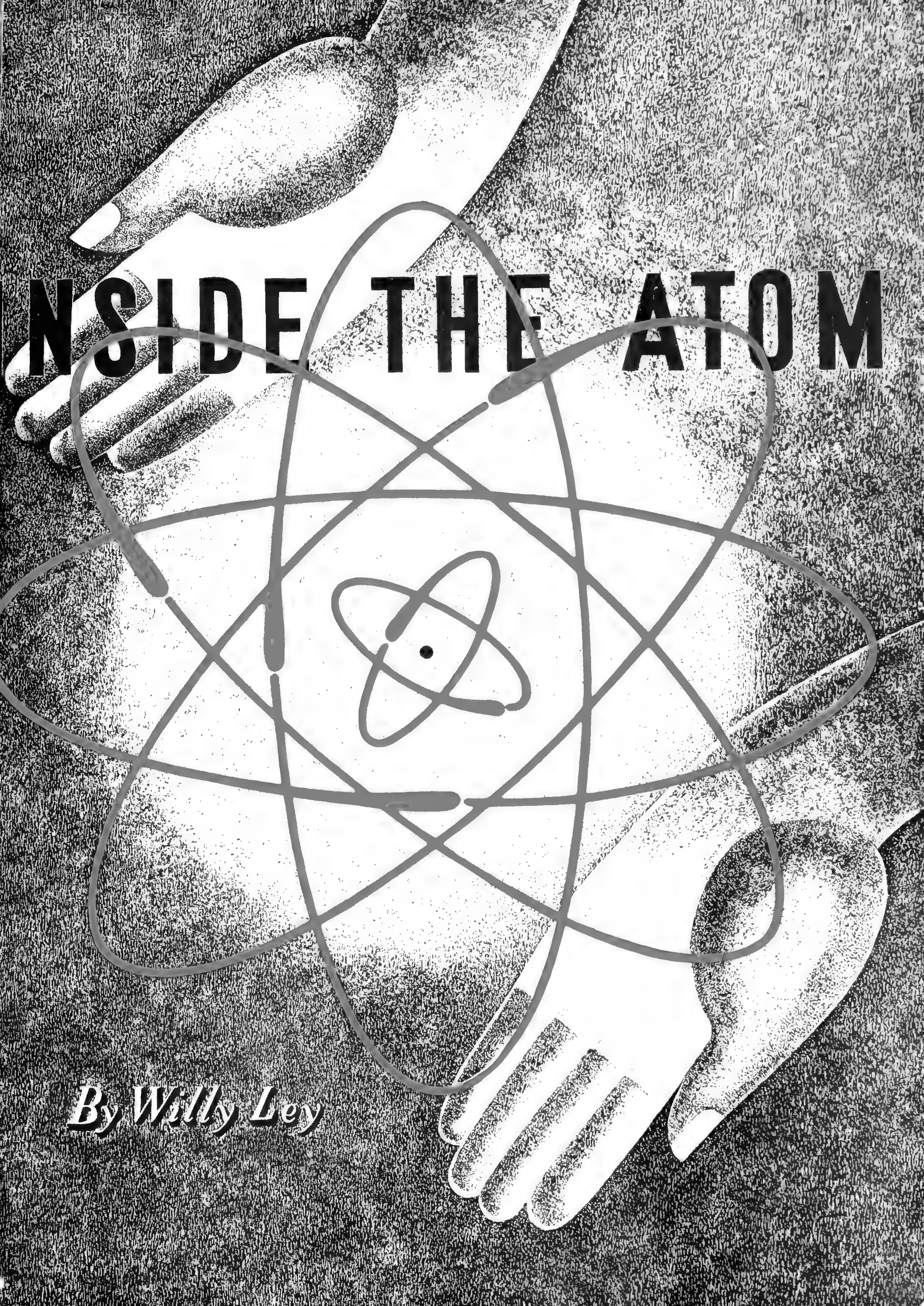
(Miscellaneous Writings)

In popular government results worth having can only be achieved by men who combine worthy ideals with practical good sense

(Address at Harvard Union, Feb. 23rd, 1907)

If I must choose between righteousness and peace I choose righteousness

(America and the World War)


NSIDE THE ATOM
By Willy Ley

INSIDE THE ATOM

By

WILLY LEY

MAN AND NATURE PUBLICATIONS

Science Guide No. 120

THE AMERICAN MUSEUM OF NATURAL HISTORY

Central Park West at 79th Street, New York 24, N. Y.

Reprinted from NATURAL HISTORY Magazine, October 1945

Man and the Atom

As the explosions of the first atomic bombs recede into time and the rubble of destruction settles on the scarred landscape, the issues raised by man's use of atomic energy become clearer. The exultation, the joy, and the relief in our minds that we had at last the power and ability to destroy our enemy completely, should he refuse to cease the struggle, are replaced by a profound concern about a future exposed to the uses of atomic energy.

Now that we have it, what are we going to do with it? This question, of course, involves more than the temporary measure of keeping its secrets safe within our own councils, for it is clear that we cannot hope to remain the sole guardian of the scientific knowledge that has made the atomic bomb possible. The basic principles are common property, and it is only a matter of time before other nations will have learned the final steps that we have already mastered. Under such circumstances, it is useless to urge that the knowledge of the means of harnessing atomic energy be obliterated in order to protect ourselves or our successors from their own folly, even if we had the moral right to deny the vast possibilities for good that are inherent in such knowledge.

The consequences, moreover, of attempting to destroy the knowledge of atomic energy, and therefore to declare it by mutual agreement to be a *terra prohibita,* would eventually result in blocking the advance of physics along other and more innocent fronts. Science cannot progress, leaving behind it unknown areas set aside and marked dangerous. Mankind is too comfortably installed on a *de luxe* express named "Science." There are no stops.

It is perhaps salutary, as we contemplate the future, to view this discovery in the perspective of human development. In a very real sense the history of man is the story of an expanding use of energy outside the human organism. The discovery of atomic energy represents only the latest achievement in acquiring sources of energy and thereby devising means of harvesting natural resources for our material and even spiritual welfare. Beginning with the use of fire, man has gradually and with quickening tempo tapped one source of energy after another. With each of these achievements, he has laid open vast areas for good as well as acquired the means of destruction. Fire itself, used by man for perhaps 500,000 years, still requires vigilance and control. Is it conceivable that men should abandon these present powers because of their latent evil? Should we give up our automobiles because they are used recklessly and unwisely by some, our radios because they are possible means of spreading pernicious propaganda, our airplanes because they may carry bombs? Who can predict what alleviations of human misery atomic energy may bring? And although we recognize the dangers, are these benefits to be rejected for fear of its misuse?

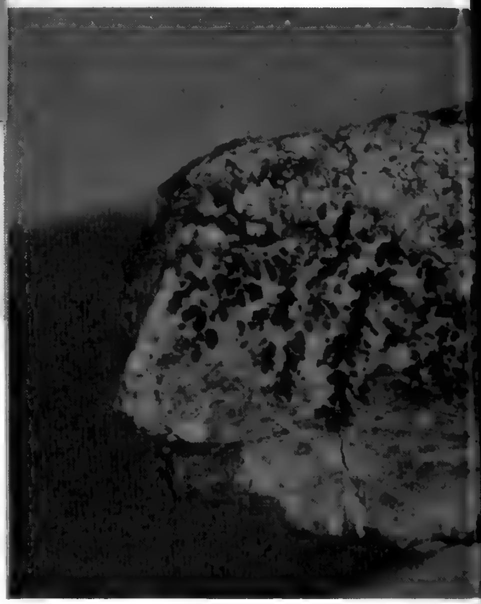
There are those who advocate that mankind should first learn moral restraint and social responsibility before being entrusted with undue power. But who shall judge when man will have reached that point in his development, and how may he achieve such virtues in the absence of the responsibilities that force him to acquire them? Moreover, it may be said that man has never been completely ready socially or morally for each new source of power that he has acquired. The apelike beings who first discovered the beneficent uses of fire were no better organized to control it than we who today have within our grasp the vastly greater quotient of energy locked in the atom.

Since, however, atomic energy is here and is likely to stay, it is the solemn obligation of scientists, particularly those concerned with human affairs, and of all men of vision, to work for a political and social organization of mankind that will, by making war impossible, permit us to employ our powers without disaster.

H. L. SHAPIRO,
Chairman and Curator,
Department of Anthropology,
The American Museum of Natural History.

Inside the ATOM

By WILLY LEY



The word the Greeks had for it meant "indivisible." Twenty centuries were necessary to show that the atom is divisible and that its energy is great enough to revolutionize peace as well as war

NOTHING in the whole history of human thought has ever received as wrong a name as the atom. Both the idea of its existence and its name originated in the world of Classic Greek philosophy. The word that is the root for our word "atom" is the Greek *atomos,* which means "indivisible." Even the man on the street now knows that nothing divides more spectacularly than the atom.

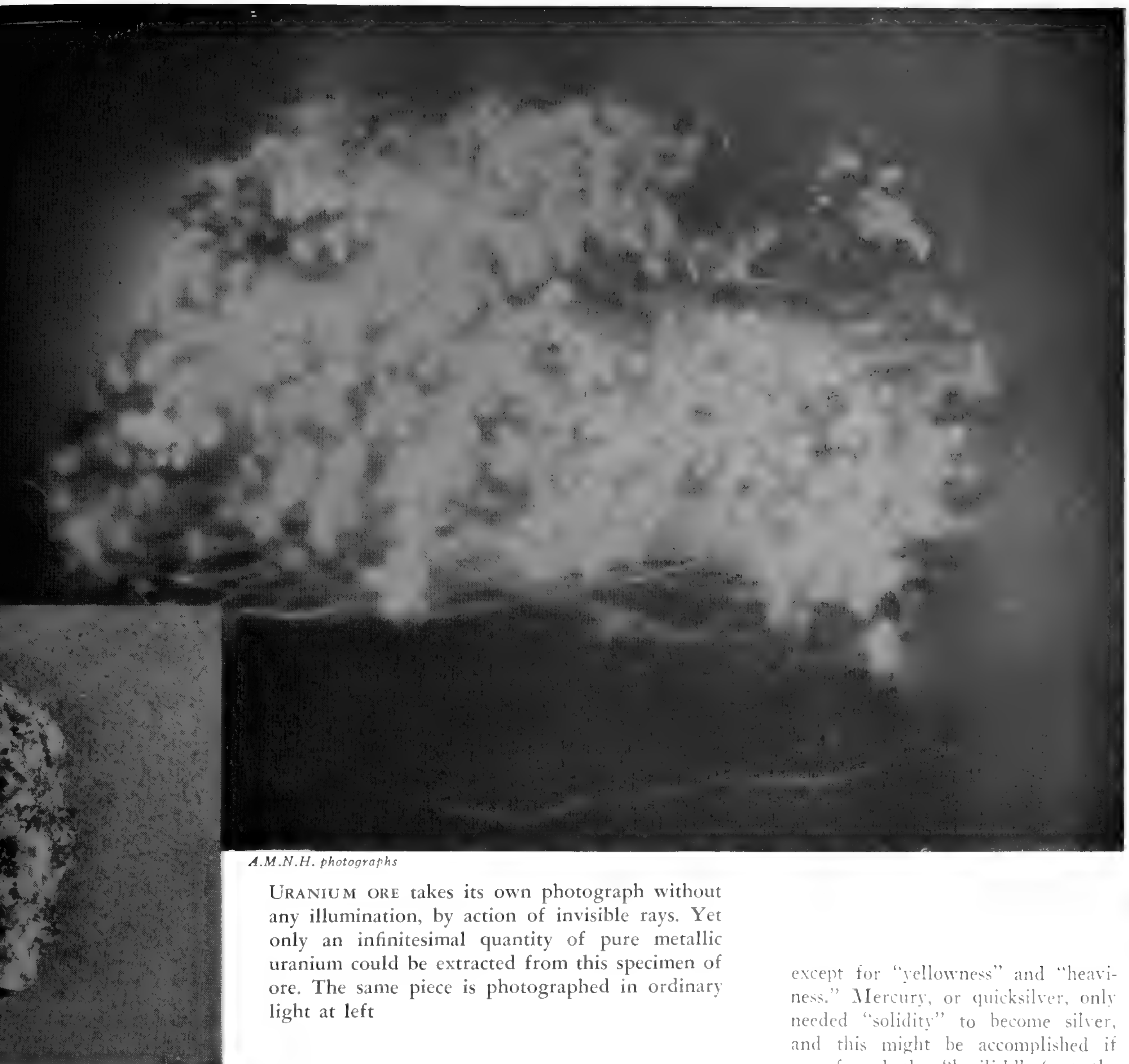
The weapon that helped to blast Japan out of the war with two enormous blows depends upon the explosion of these "indivisible" particles, which contain the most incredible amounts of energy.

Like all ideas, the concept of the atom as the ultimate particle of matter grew from small and simple beginnings. The best way to understand what has been done during the last four years under extreme secrecy in American laboratories is to trace the growth of that idea. The "father" of the atom was a Greek natural philosopher, Democritus the Abderite, who was born in Abdera in Thrace in about 460 B.C. That he followed, in part, the teachings of one Leucippus who lived about half a century earlier should not detract from his glory.

Students at the time of Democritus were groping for an explanation of the basic differences between various substances. Democritus argued that all substances must consist of a number of fundamental pieces. Thus the idea arose that water was composed of particles that were very round and smooth (as we would say, like small polished steel balls) and therefore easy to part, while the atoms of iron were rough and therefore difficult to part. Atoms of acid were supposed to be covered with little hooks which made them sharp and grasping.

These particles differed in shape and arrangement and possibly in magnitude and weight. Also they were capable of movement. But their chief peculiarity was that they were indivisible. Each was so small that it could not be reduced further; hence the word "atom."

All this sounded reasonable enough, and the idea of indivisible atoms retained its validity with but little change until half a century ago. People assumed that there had to be an



A.M.N.H. photographs

URANIUM ORE takes its own photograph without any illumination, by action of invisible rays. Yet only an infinitesimal quantity of pure metallic uranium could be extracted from this specimen of ore. The same piece is photographed in ordinary light at left

irreducible particle, and atoms filled the bill.

It should be remembered that Democritus' atoms were purely philosophical and not supported by any experimental evidence. They were as much the product of belief as of reasoning; therefore, nobody was obliged to accept their existence. Aristotle had no use for them, and while his biting criticism failed to kill the idea of atoms once and for all, the atomists did not rise to a dominant position in natural philosophy and remained but *one* philosophical school among many.

Throughout the Middle Ages the idea remained static. The alchemists did not like "unchangeable" atoms, because their goal was the transmutation of metals, particularly the making of gold from baser elements. Some alchemists, to be sure, had idealistic goals such as the *aurum potabile,* or "drinkable gold," which was to cure all ills. But most of them were content to try for solid gold, stating euphemistically that they were looking for the Cure for the Great Illness of Poverty.

They had their own theories to go by. Chalk, for example, was thought to be the same as sulphur, except that chalk lacked "yellowness" and "combustibility." If you could impart "yellowness" and "combustibility" to chalk, you would have sulphur. Likewise, silver was the same as gold except for "yellowness" and "heaviness." Mercury, or quicksilver, only needed "solidity" to become silver, and this might be accomplished if you forced the "basilisk" (not the same as the "king of serpents" of medieval zoology, but a demonic concept) in the mercury, to part from it. If in addition, you could impart "yellowness," say from sulphur, you would have gold.

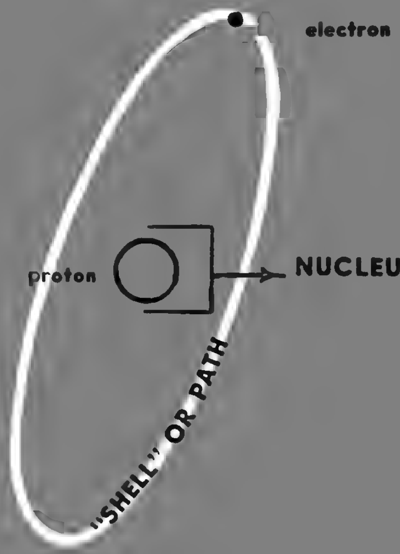
In the course of time, theories of alchemy disappeared to make room for other ideas which, although wrong in themselves, were much more effective because they led to more systematic experimentation.

Around the year 1800 the time was evidently ripe for the revival of the atoms of old. This was done by an English chemist, John Dalton, whose ideas had been directed into atomistic channels, curiously enough, through the avenue of weather observations. Seeing rain fall and disappear again,

WHAT IS AN ATOM?

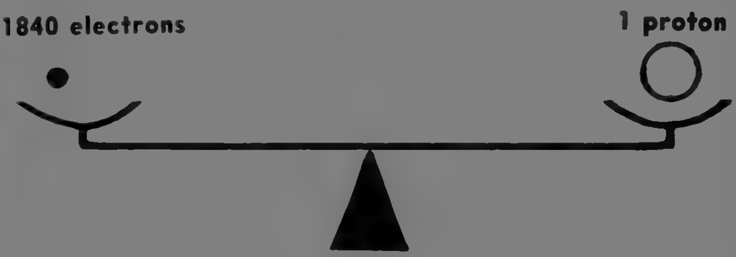
1

A HYDROGEN ATOM has one proton (a positively charged particle) as a central mass, or nucleus. This is balanced by one electron (negatively charged) moving around it



2

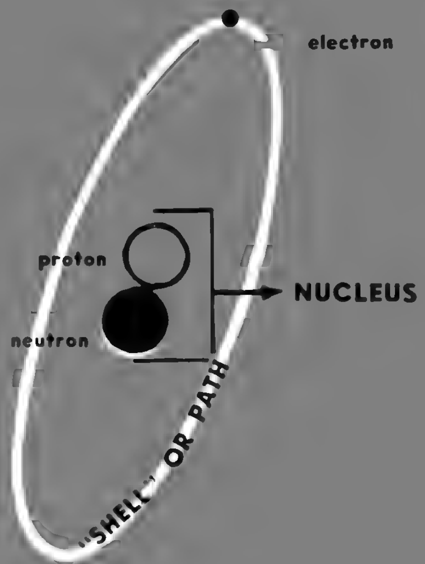
IT takes 1840 electrons to equal the weight of one proton



The whole atom is so small that it is far beyond the range of the electron microscope

3

BESIDES ELECTRONS and protons there are also neutrons, particles that are neutral in the electric sense but have weight. If there is a neutron in the hydrogen nucleus, we have "heavy hydrogen," which forms "heavy water"



Dalton could think of no other explanation than that both water and air consisted of tiny separate particles; otherwise the evaporating water could not enter the air. Observations in the chemical laboratory helped this idea along. Hydrogen and oxygen combined to form water always in a given and rigid weight ratio, no matter how it was done.

After enough facts of this kind had been amassed, Dalton was able in 1808 to write the following:

"These observations have led to the conclusion which seems universally adopted, that all bodies of sensible magnitude, whether liquid or solid, are constituted of a vast number of extremely small particles, or atoms of matter, bound together by a force of attraction, which is more or less powerful according to circumstances. . . . Chemical analysis and synthesis go no farther than to the separation of particles one from another, and to their reunion. No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen. All the changes we can introduce consist in separating particles that are in a state of cohesion or combination, and joining those that were previously at a distance."

Dalton's words became the basis of chemical thought for a full century, and still hold true for chemistry proper. He said, in brief, that all chemical elements consist of minute particles that cannot be subivided further—in other words, atoms. These atoms could form an enormous number of combinations with one another. The smallest possible particle that represented such a combination then recevied a new name, molecule (meaning "small bundle") and the customary classroom explanation sounded like this: By mechanical means, as for example through evaporation, you can divide and subdivide a droplet of water until you arrive at a very small quantity, the water molecule, that can no longer be subdivided and still be water. If you take that molecule apart, you no longer have water but only the elements composing it—in this case, two atoms of hydrogen and one of oxygen.

It rapidly became clear that the atoms of the elements were not all of the same weight. The atom of hydrogen had to be lighter (and presumably

smaller) than that of carbon. The carbon atom, in turn, was lighter than the oxygen atom, and the oxygen atom lighter than that of silver. The weight of the atom did not, however, determine the weight of the substance. The atom of gold, for instance, is lighter than the atom of lead, though gold itself is heavier than an equal volume of lead. The atoms of gold happen to be more closely packed.

The relative atomic weight of hydrogen was arbitrarily called "1," and the carbon atom was found to be about 12, that of oxygen almost precisely 16, silver about 108, gold about 197, and lead about 207. These weights were only approximate, but the differences were small. And the English chemist Prout, as early as 1815, ventured the guess that these small differences might be merely mistakes and that all the elements were probably just combinations of various numbers of hydrogen atoms.

This sounded intriguing, especially since it recalled another guess of the alchemists, namely that there was a primary substance, a *prima materia,* of which all other substances were composed. But Prout's idea could not be proved, because the small "mistakes" were stubborn and persistent. Sometimes the figures underwent slight changes when improved methods were used, but they never became the even figures that Prout's guess demanded.

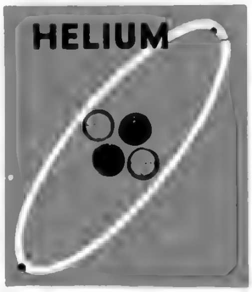
Later in the century, however, a different type of progress was made along similar lines. Two chemists set out, independently and at about the same time, to arrange the known elements in a logical order according to their atomic weights. They finally succeeded in doing this by leaving a few holes in their tabulations, holes which they hoped and predicted would be filled later by the discovery of additional elements. That was in 1869, and the names of the two men were Lothar Meyer and Dmitri Ivanovich Mendelyeev. Both came to about the same conclusions, but Mendelyeev's name became attached to this Periodic System of the Elements, mainly because he had made several very good predictions about the then unknown elements. One after another, the holes in the table were rapidly filled in, but one of the newcomers was so unusual that it looked for a moment as though the whole Periodic System would have to be thrown out on its account.

That newcomer was radium. The

KINDS OF ATOMS

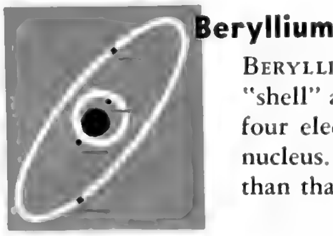
THE ELEMENTS, such as gold, silver, oxygen, etc., have long been considered the basic substances that cannot be separated into different substances, only combined with each other to form compounds

Each element is made up of its characteristic atoms, which differ in the number and distribution of their electrically charged particles



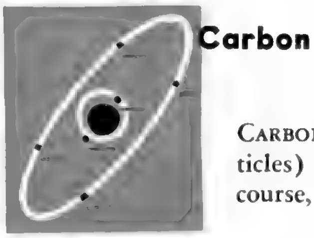
THE HELIUM ATOM is almost as simple as the hydrogen atom. But it has two positive protons in the nucleus and two electrons to balance them. Its greater weight, however, shows that the nucleus has also two neutrons

LITHIUM has three protons in the nucleus (here shown simply as a solid body). The three electrons that balance them cannot all get on the inner path, or "shell." One of them is farther out

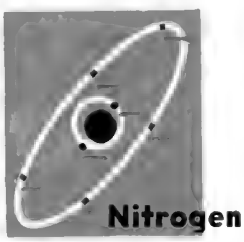


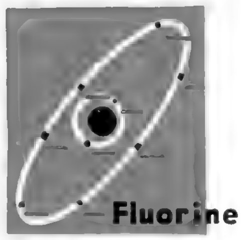
BERYLLIUM has two electrons on the inner path or "shell" and two on the outer one To balance these four electrons, there must be four protons in the nucleus. The beryllium atom is therefore heavier than that of lithium and helium

BORON has five electrons on the two paths or "shells." These "shells" can accommodate a total of ten, and when they do, the atom is said to be "satisfied." The boron atom is not "satisfied" and therefore will readily combine with other elements



CARBON has a total of six electrons (negative particles) in the two shells. They are balanced, of course, by six protons (positive) in the nucleus





NITROGEN, oxygen, and fluorine have seven, eight, and nine electrons respectively. The same number of protons balance them in each case

NEON has all ten electrons that can be accommodated on the first two paths or "shells." It is therefore "satisfied" and is a chemically inert element

[illegible] derived from the Latin [illegible] ("ray"), described its main peculiarity. It was then found that other substances also gave off radiant energy. One of these was uranium, atomically the heaviest of all known elements and therefore number 92 in the table. It was named uranium in 1789, the year of its discovery, because the planet Uranus had become known some eight years earlier and Klaproth, the discoverer of uranium, meant to honor the astronomical discovery by transferring the name of the new planet to his new element.

A new science sprang into being at the beginning of the present century, the science of radioactive substances. John Dalton had not been able to explain evaporation without assuming that all matter consisted of tiny particles. Radioactivity now compelled its investigators to assume that the very heavy atoms at the upper end of the periodic table emitted still smaller particles. It seemed that these very large atoms,—those of radium, actinium, uranium, etc.,—had grown too large to hold together very well. They decayed and in decaying gave off radiation, which is energy in the form of particles smaller than an atom, subatomic particles.

Sir William Ramsay, one of the investigators of the new mystery, could not refrain from writing a poem, which he titled "The Death Knell of the Atom":

. . . So the atoms in turn, we now
clearly discern
Fly to bits with the utmost facility;
They wend on their way, and, in
splitting, display
An absolute lack of stability.

Electrical research tied in with these discoveries of the instability of the heavy atoms. Physicists had arrived at the conclusion that electricity was discontinuous, that it had to consist of particles of some kind. A flow of electricity was not like the steady beam from a searchlight, but rather like the stream of bullets from a machine gun. The smallest particles were called electrons, from the word the Greeks had for amber, the substance which when rubbed would pick up bits of paper.

These negatively charged particles (electrons) turned out to be one of the building stones of the atoms. It was a logical sequel that there must be particles having an opposite or positive electric charge, but although their manifestations had been discovered as early as 1886, they were not named until 1920. They were called protons, and it can be remembered that they are positive because both words begin with "p." It was found that these protons, while carrying a positive charge of the same amount as an electron, were much more massive. The best figure at pres-

ent says that one proton has the mass of 1840 electrons.

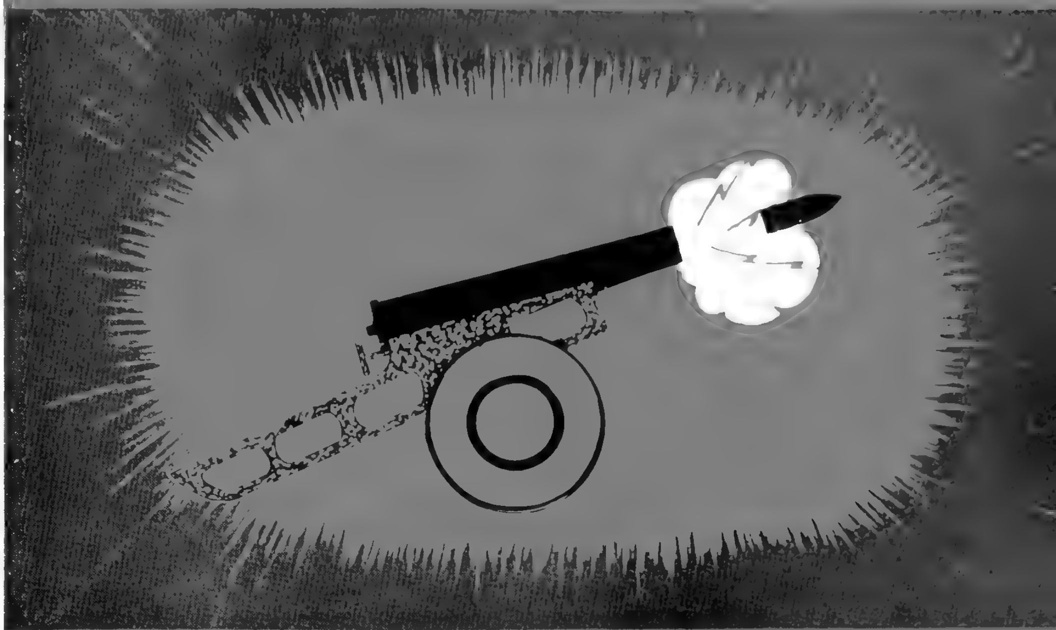
It was about that time that Niels Bohr evolved his famous theory of atomic structure. While there have been other attempts to describe the atom, Bohr's has best stood the test of time, and it is the only one that is easy to visualize. According to his theory, an atom can be compared to the solar system, in which the various planets move in curved paths around the sun. In the center is the main mass, the nucleus or heart of the atom, carrying one or more positive electric charges. Around the nucleus whirl planet electrons, as many as are required to counter-balance the positive charge of the nucleus. We might say that the atom is a positively charged mass surrounded by a veil of negative electricity.

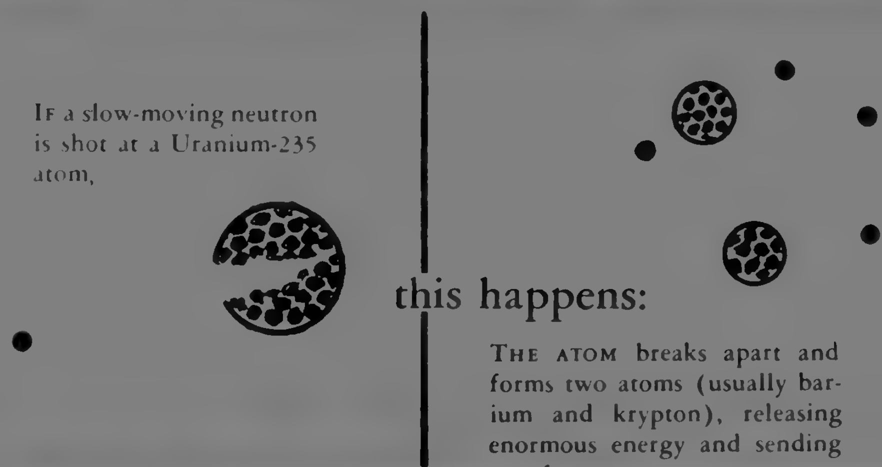
Now the mass of one proton is just about the same as the mass of a hyrogen atom. Therefore it was reasoned that a hydrogen atom consisted of one proton in the nucleus, circled by a single tiny electron.

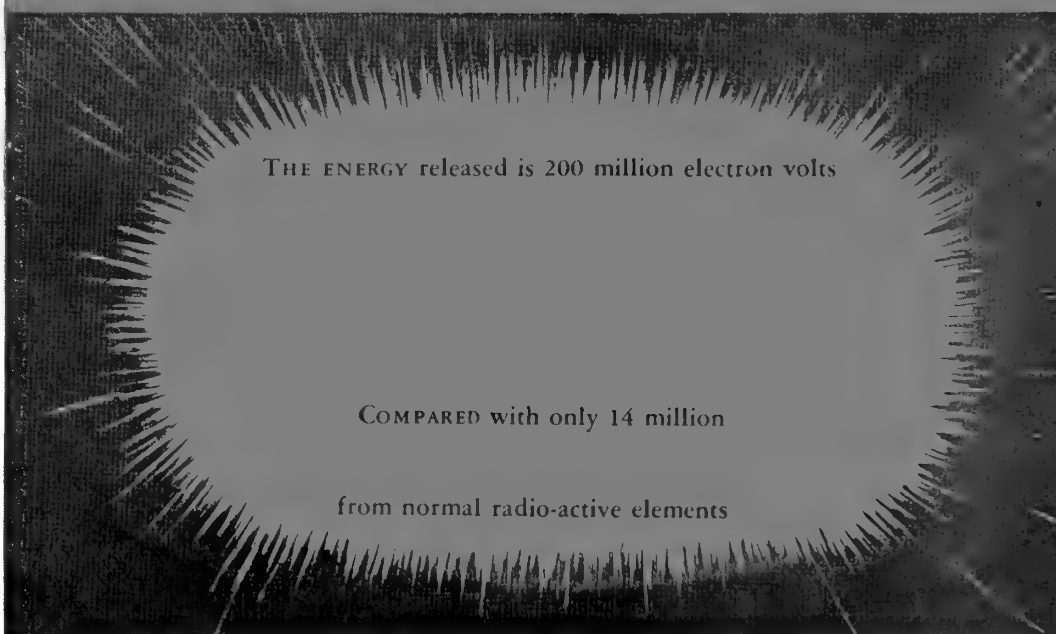
Hydrogen is element number 1 in the atomic table, with a weight of 1.008. Element number 2 is helium, with a weight of 4.003. But the nucleus of this atom, also called alpha particle, carries only two positive charges electrically balancing its two electrons. This would add up to only little over half the known atomic weight of the helium atom. Apparently there had to be a mass in the nucleus without any electric charge. It was at this point that a suggestion made by Lord Rutherford of Nelson in 1920 proved useful. Rutherford had suggested the existence of a subatomic particle called a neutron—in other words, a particle that was neutral in the electrical sense. It was said to have the same or about the same mass as a proton, but without any charge. The nucleus of helium, consequently, was understood to consist of two protons and two neutrons, with two electrons moving around it in a single orbit.

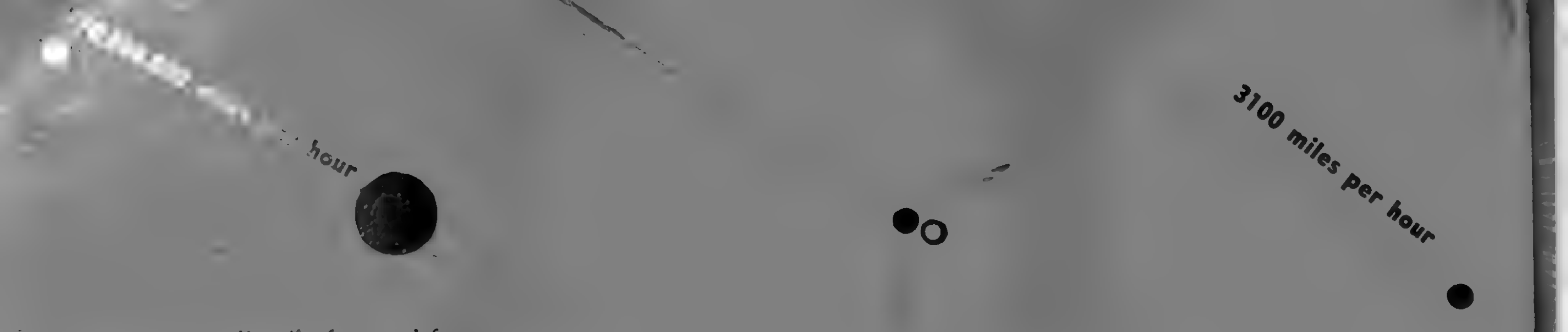
Element number 3, lithium, has an atomic weight of about 7; hence its nucleus contains three protons and four neutrons, with three relatively weightless electrons circling round it. Two of these electrons were the same in position and arrangement as those of helium, but the third electron moved in another orbit farther out. That second orbit, or "shell" as it is known technically, can take up to eight electrons; then it is full, or

THE BEHAVIOR of radio-active elements suggested how the atom might be smashed. A radio-active atom can be compared to a cannon. The bullet is the so-called alpha particle (or helium nucleus). The smoke is the beta "radiation." And the flash is the gamma radiation









NEUTRONS are ordinarily fast, and fast neutrons will not break the uranium atom. They merely bounce off without suffering measurable loss of speed

BUT when a fast neutron hits hydrogen atom of about the same weight, the two share the energy

AFTER many bounces, the neutron is slowed down

"satisfied." This is the case with neon (element number 10), in which ten electrons balance a nucleus containing ten protons and ten neutrons, to give an atomic weight of about 20.

Element number 11, sodium, had one more electron still farther out, in a third shell. If the outer shell in any instance is full or satisfied, we have an element that shows no inclination to form any compounds, for instance helium, neon, and with more shells, argon, krypton, and xenon. But if the outer shell is not full, chemical activity results. Sodium atoms have one electron in the third shell, chlorine atoms have seven. These two elements combine very readily. But all these chemical combinations take place in the outer shells; they do not touch the nuclei. Hence atoms go into chemical compounds and out of them again without experiencing any change. If you want to change the atom itself, you have to attack the nucleus.

The attack on the nucleus, popularly called "atom smashing," became the big problem. Obviously, the only way in which one could attack the very small nucleus was to shoot at it with still smaller particles. The behavior of the radioactive elements themselves suggested what might be done. When a radioactive atom convulsed, it shot out an alpha particle (or helium nucleus) accompanied by two types of radiation, called beta and gamma rays. The beta "rays" were streams of electrons. The gamma rays were true radiation, comparable to the very hardest variety of X-rays.

To help us visualize this occurrence, there is a beautiful comparison. The emission of an alpha particle corresponds exactly to the firing of a gun. The heavy alpha particle is like the bullet. The beta "radiation" is the smoke, less substantial and lighter. And the burst of gamma radiation is the flash, impressive but non-material. The same gun, needless to say, was fired back at the atom in the effort to break it.

All the machinery that received newspaper publicity from time to time—the van de Graaff generator and finally the cyclotron—were only atomic cannon. They were machines designed to fire subatomic particles, especially alpha particles, protons and deuterons, into atoms. Physicists learned a great deal while inventing, constructing, and using this machinery. The dreams of the alchemists were realized to some extent: some elements were actually changed into others. Atoms were hit and chipped; but the military significance of these experiments was not too impressive. Most of the time, the damage was only comparable to a hole put through the funnel of an enemy steamer. Only very rarely was an atom really broken up. Especially obstinate in the face of the bombardment were the heavy atoms, which one could assume might ultimately be the most satisfactory targets.

Then, in 1939 and 1940, the great problem was solved, at least in one particular case, the case that led in a straight line to the atomic bomb. The Italian physicist Enrico Fermi, later of Columbia University in New York, working with uranium, made an observation that could not even be explained at first. For a short time Fermi thought that he had discovered a new element. Other researchers took up the trail, and in view of the political events then brewing, the situation became critical, for they were German scientists—Drs. Hahn, Strassmann, and Lise Meitner. Dr. Meitner left Germany and aided the scientists of the United Nations.

They found that what had happened was an absolute novelty. A uranium atom had not simply had pieces chipped off by a subatomic bullet: it had exploded like a torpedoed ship! The nucleus had broken into two pieces of approximately the same mass, sending out streams of energy on an unprecedented scale. Physical science even lacked a term for this performance and had to borrow the word "fission" (a cleaving, or breaking up into parts) from the biologists.

It was the first time that one of the really heavy atoms had yielded, and it had yielded not so much to brute force as to persuasion. Not a fast-moving alpha particle but a slow-moving neutron caused the fission of the uranium atom. But not every uranium atom responded.

It had already been learned that the established elements sometimes masqueraded in slightly different costumes. The so-called "heavy water" that was recently discovered is "heavy" because its hydrogen atom is one of these variant forms. Likewise, in addition to the usual helium 4, there is helium 3, with only one neutron instead of two; and there is lithium 6 as well as lithium 7. Chemically there is no difference, but the atoms have different weights. These variant forms of an element are called isotopes.

In the case of uranium, there were U-234, 235, 236, 237, and 238, the last being the most common type. U-236 and U-237 are not stable; U-234 is very rare; but U-235 is compartively abundant, one out of every 140 uranium atoms being of this type. And U-235, with 143 neutrons instead of 146, goes into fission as soon as a slow neutron wanders in.

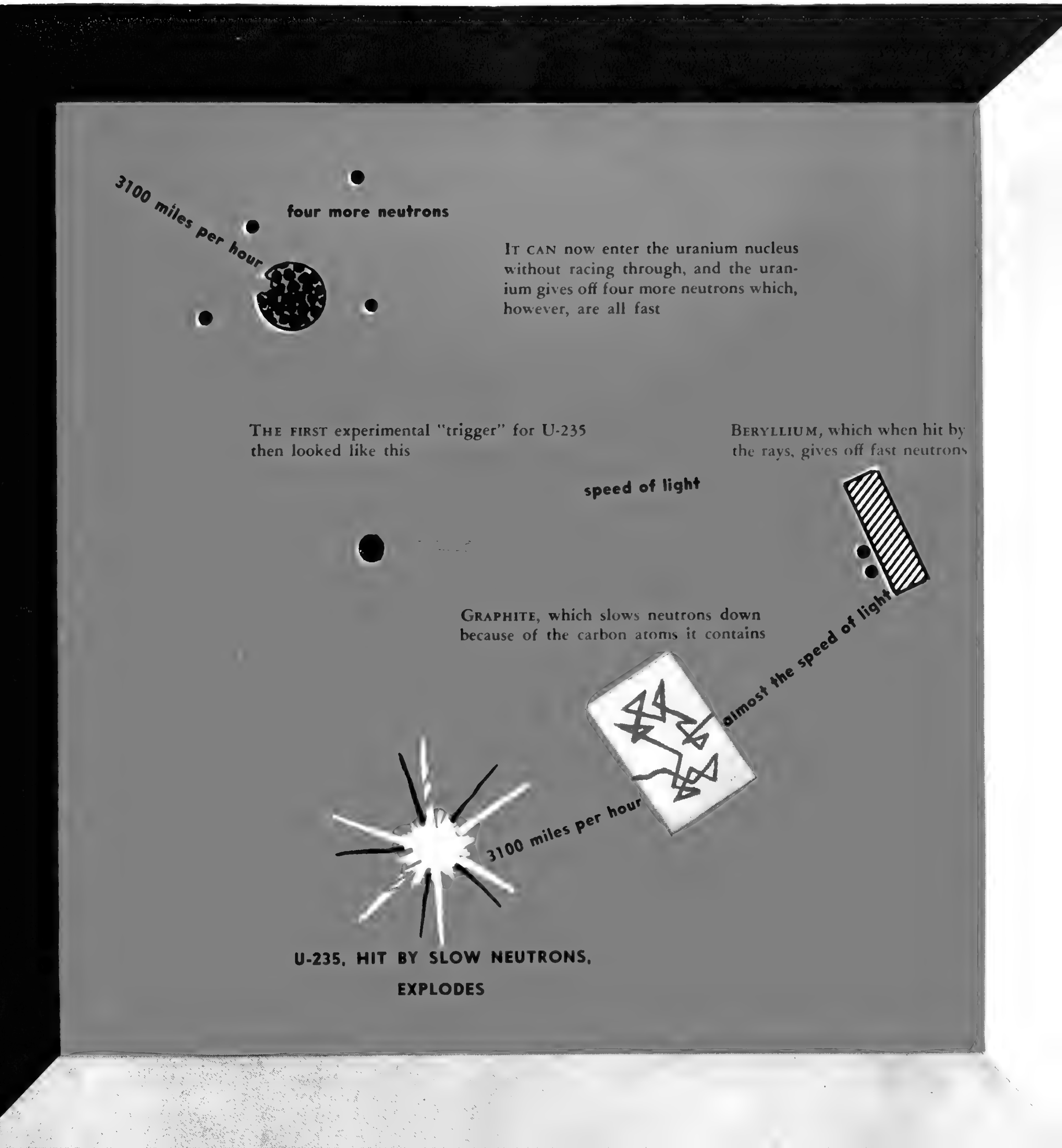
The explosion or collapse (either term applies, depending upon the point of view) is restricted to that one atom. The atom gives off four additional neutrons in the process of breaking up, but these are fast neutrons and therefore do not touch the nuclei of other atoms. It seems that

a fast neutron, when it runs into a heavy atom of any kind, mostly just bounces off without apparent loss in speed.

The two problems that arose as soon as these facts were known were: (a) how can one extract U-235 in large quantities from the customary mixture of U-238 and U-235, and (b) how can one slow down those four neutrons that are released so that they will in turn cause other atoms to explode and produce what is called a chain reaction.

The problem of separating U-235 from regular uranium (U-238 plus U-235) was extremely tedious, as can be imagined from the size of the factories that had to be built to make the atomic bomb. There existed, in 1940, an instrument called the mass-spectrograph. It operated somewhat on the principle of a cream separator, the slightly heavier U-238 being separated from the lighter U-235 by means of a magnetic field which affected them differently. But one single mass-spectrograph would have to be kept running 24 hours a day for about 12 million years to sort one pound of U-235 atoms from the necessary amount of purified metallic uranium.

One way would have been to put 12 million machines to work and get a pound of U-235 in one year. To obtain a yearly production of 400



[illegible] the amount the Hiroshima bomb may have contained, would require 4800 million machines.

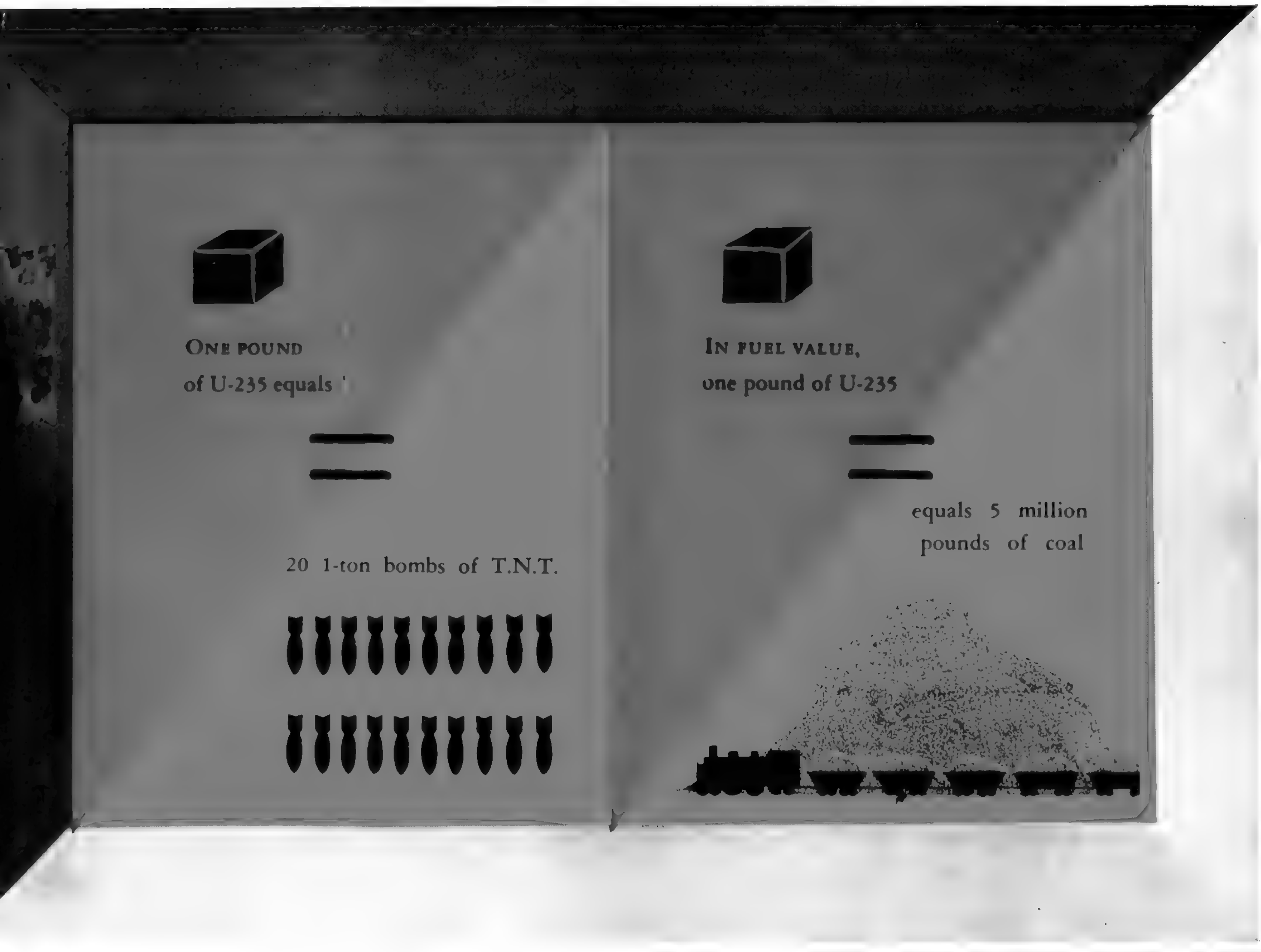
Another possibility (and this was purely hypothetical in 1940) was to do something with U-238 to *convert* it, in some manner, into some other material. Irradiation of uranium with neutrons produced a new uranium isotope, U-239, which does not exist in Nature. This decays into a new substance, called neptunium because the planet Neptune is *beyond* Uranus in the solar system. This substance was not stable. It changed into still another new substance called, for similar reasons, plutonium.

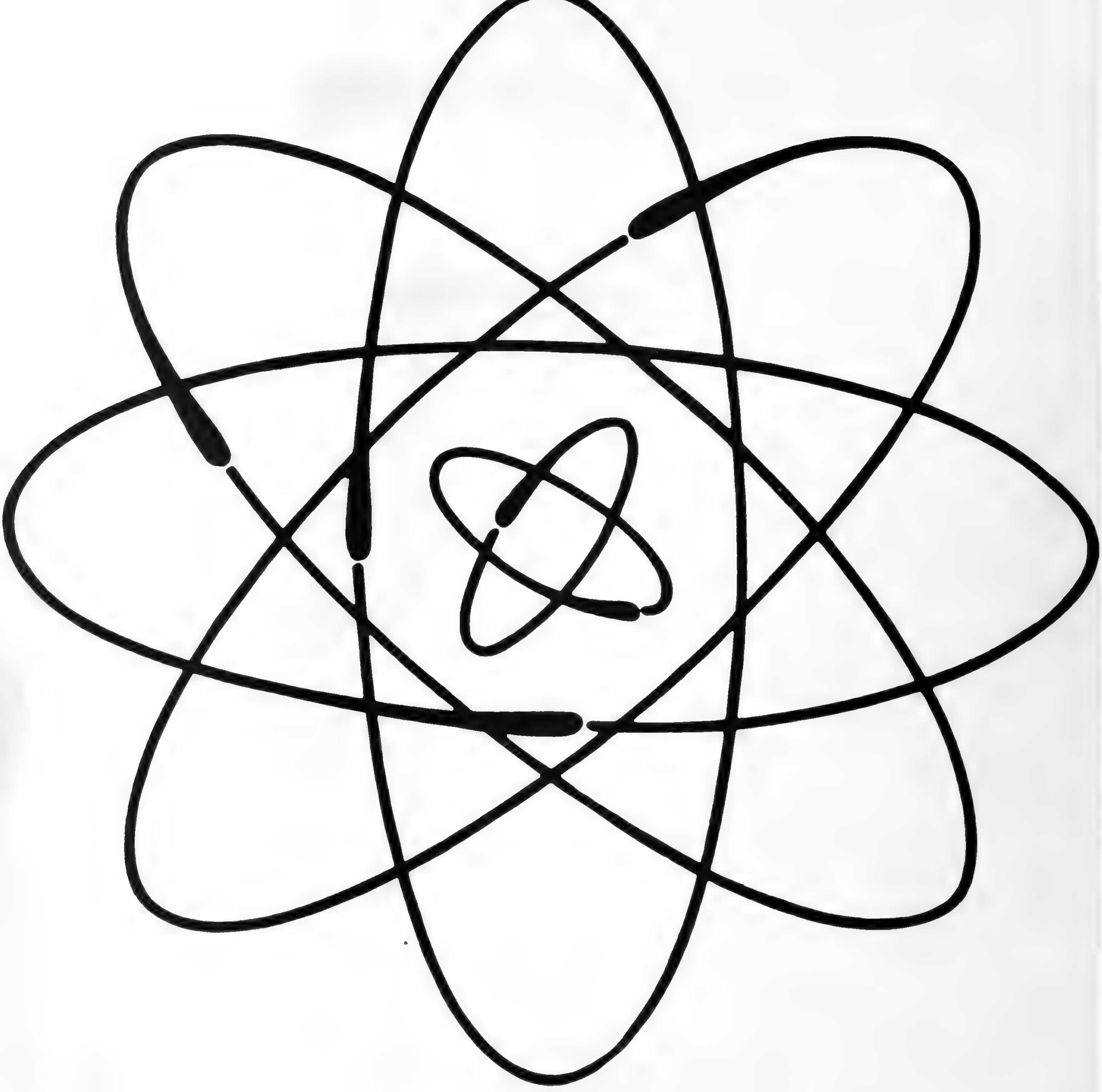
Plutonium, it seems rather certain, is stable to a certain extent and fissionable like U-235. But a difference is hinted at in a cautious report prepared by Prof. Smyth of Princeton University at the request of the War Department. Apparently plutonium fissionizes like U-235 when its mass is small, but once the mass approaches what has been called the "critical size," it will go into atomic explosion. This characteristic suggested an application that could be used in military operations. If enough plutonium to produce an atomic explosion could be kept in separate pieces, so that each piece were well below the "critical mass," and then could be brought together rapidly, the whole would explode with tremendous violence.

Part of the answer to the second problem—how to produce a chain reaction—is no secret. A fast neutron will bounce off a heavy atom without measurable loss of speed. But if it runs into a light atom, like a hydrogen or carbon atom, which has little more mass than the neutron itself, the bounce is mutual, and the two bodies share the original speed of the neutron. This means that a neutron which has been bounced around in a dense swarm of light atoms for a time will have slowed down enough to set off additional uranium atoms. In practical terms it means that the U-235 should be surrounded by a compound rich in hydrogen atoms, such as paraffin or simply water, or one rich in carbon atoms, such as graphite.

That should create a more or less fuel-like slow reaction, very useful for peaceful purposes, but not suitable for bombs. The method of setting off all the atoms at once remains one of the most closely guarded military secrets.

The bombs which helped to end the War prove that atomic energy can now be used at will. So far, we have only been able to explode the atoms of the rarer isotopes of uranium and its heavier derivatives. In appearance U-235 is a silvery metal, slightly softer than soft steel and about as heavy as gold. Gold has a specific gravity of 19.3, while that of uranium is 18.7. But having found the key to one element's nucleus, we'll probably find the keys to others' too. And the peacetime possibilities of atomic energy are even more boundless than its destructive power in war.





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